1981

Graduate Catalog 1981-83, Iowa State University Bulletin

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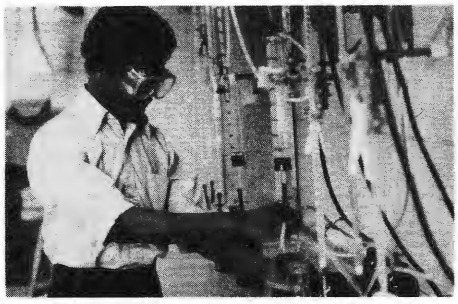

Iowa State University of Science and Technology Ames Iowa Iowa State University Bulletin Graduate College Catalog 1981'83

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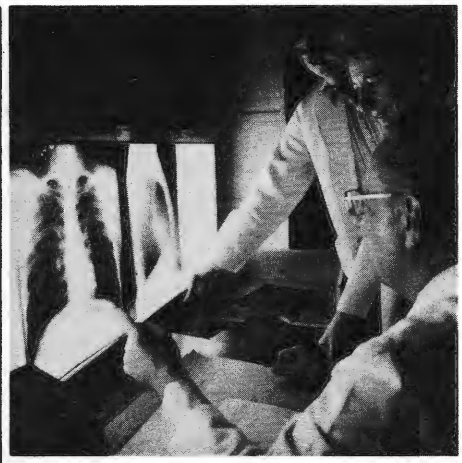

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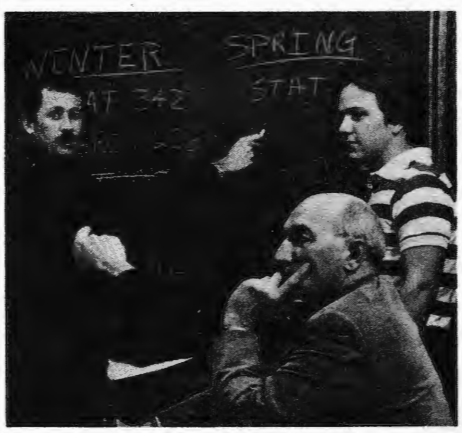

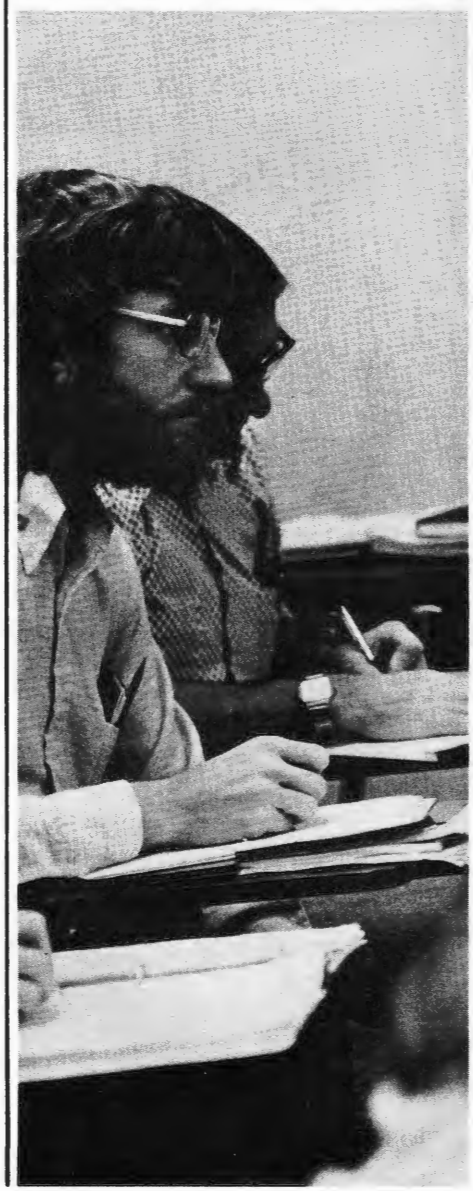

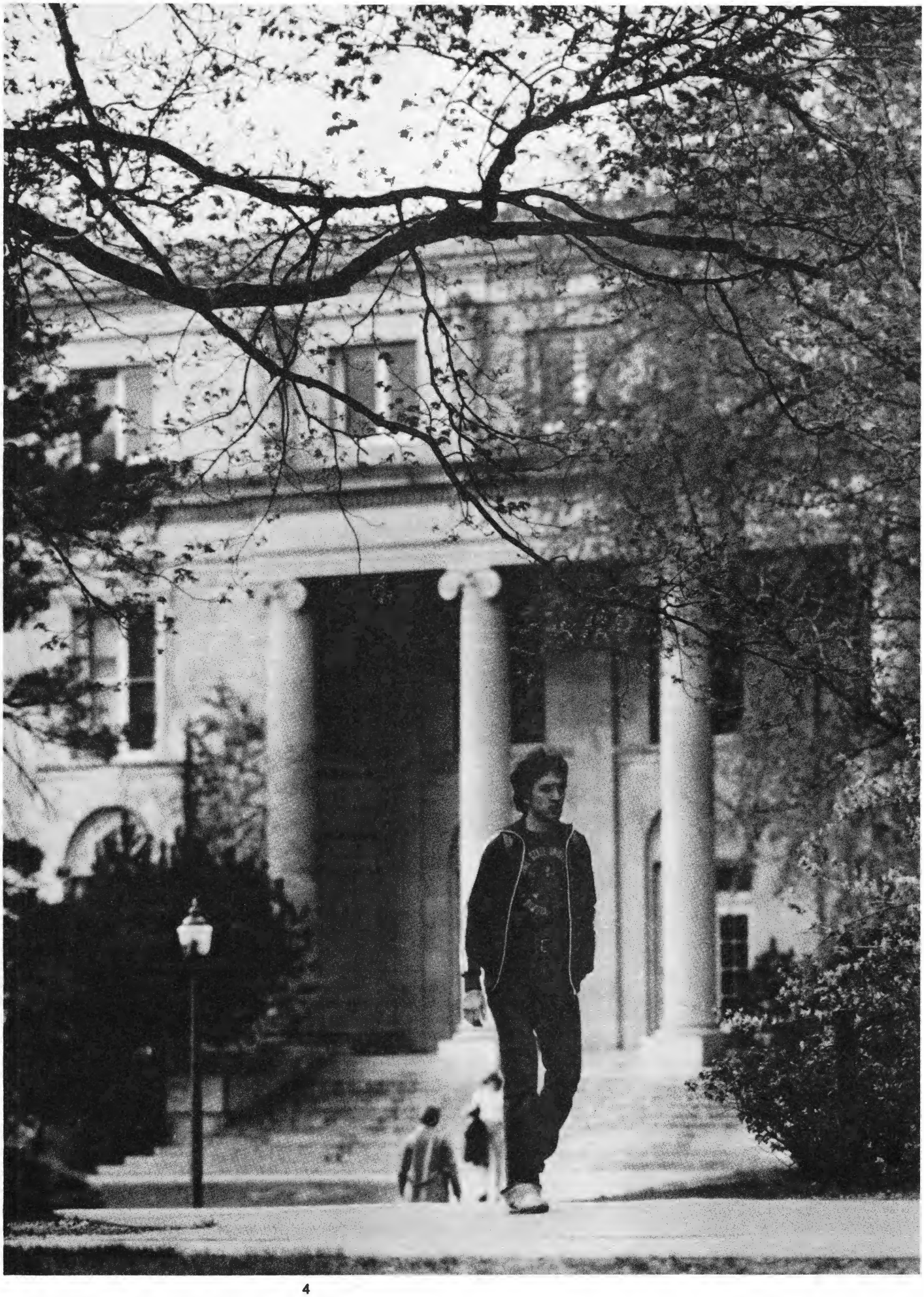

The University

Iowa State University was one of the earliest institutions established in the movement to create an educational system uniquely suited to American democratic philosophy.

It was chartered by the Iowa General Assembly in 1858. Four years later the national "people's college" movement was underwritten by the Morrill Land-Grant Act. The act made federal lands available for sale to endow colleges whose aim was to promote "liberal and practical education . . . in the several pursuits and professions of life."

Originally these colleges were primarily concerned with subjects relating to agricultural and industrial pursuits. Thus this institution was chartered as the "Iowa Agricultural College," and in 1896 was given the more inclusive name, "Iowa State College of Agriculture and Mechanic Arts." In those beginning years it established a national — and in many cases international — reputation in the areas of agriculture, veterinary medicine, home economics, and engineering.

Adapting land-grant philosophy to the changing needs of the twentieth century, Iowa State has maintained its preeminence in these areas, but has broadened and strengthened its work in other areas to the point that its largest enrollment now is in the sciences and humanities.

Increasing numbers of students find in the broad-based curriculum of Iowa State opportunities to specialize in excellent programs of science and technology, and to acquire a broad general background of education in the liberal arts tradition.

This Iowa State University Bulletin is a general catalog of information regarding fees, curricula, and related policies and procedures. Every effort has been made to make the bulletin accurate as of the date of publication; however, all policies, procedures, fees, and charges are subject to change at any time by appropriate action of the faculty, the university administration, or the State Board of Regents.

The Development of the University

Iowa was the first state to accept the terms of the Morrill Land-Grant Act. In March, 1863, the General Assembly awarded Iowa's grant to the recently chartered institution at Ames. The school opened its doors to a preparatory class in the fall of 1868. Instruction at the college level began the following March. A class of 26 was graduated at the first commencement in 1872. In the 1979-80 academic year more than 4,500 baccalaureate, advanced, and Doctor of Veterinary Medicine degrees were awarded.

Iowa State pioneered in the establishment of agricultural curricula, was the first state institution to found a veterinary school, and helped move engineering from a small and narrow profession to its present key position in our industrialized society. The basic sciences were emphasized. Coeducational from its beginning, Iowa State took leadership in domestic economy (later to become home economics).

Graduate study was offered almost as soon as classes began, and the first graduate degree was conferred in 1877. Experimentation and research also started early, first in agriculture and shortly thereafter in home economics, engineering, science, and veterinary medicine.

Iowa State shared the conviction with other land-grant institutions that all people should have access to the ideas and knowledge of the campus. By 1870 it was holding educational institutes in various Iowa towns. In 1903 Iowa State set the pattern of county cooperative extension as it is conducted now throughout the United States.

Iowa State's program became that of a university with special teaching responsibility in science and technology, an extension education program throughout the state, and extensive research interests to advance the frontiers of learning.

Since 1959 it has been known as Iowa State University of Science and Technology. Its continuing development in recent years has included the establishment of the College of Education, the College of Design, and the School of Business Administration.

Accreditation, Sessions, and Enrollment

Iowa State University is accredited by the North Central Association of Colleges and Secondary Schools as well as by appropriate professional organizations, and is a member of the Association of American Universities.

Instruction is offered throughout the year. Prior to 1981, the University's academic year was divided into three quarters. Effective as of fall 1981, however, the academic year is divided into two semesters of sixteen weeks each, beginning in late August and ending in mid-May.

In 1980, Iowa State had an enrollment of more than 23,500 and a faculty of nearly 2,000.

Nondiscrimination and Affirmative Action Policy

Iowa State University reaffirms its commitment to comply with all applicable federal and state civil rights laws, regulations, and orders.

In keeping with this commitment, the University will ensure that all decisions pertinent to employment, conditions of employment, programs, activities, services and the use of facilities shall be rendered, with few exceptions, without regard to age, color, known handicaps (mental or physical), national origin, race, religion, sex, or status as a disabled veteran or veteran of the Vietnam era. Exceptions to this policy may be made in matters regarding bona fide occupational qualifications, business necessity, and to eliminate problems attendant to underutilization. Race, sex, or other such factors, when used for the purpose of reducing underutilization, must be only one of several factors considered in the selection of otherwise qualified personnel.

Further, the University will regard any act of sexual harassment which contains a threat or insinuation that the lack of sexual submission will adversely affect a person's employment, conditions of employment, academic standing, receipt of services, or other conditions which affect his or her livelihood as a violation of university policies subject to appropriate disciplinary action.

This policy applies to all university-sponsored programs and activities as well as those which are planned or conducted under the University's auspices.

Any person who believes that he or she has been the recipient of a discriminatory act prohibited by this policy may file a grievance with the University's Affirmative Action Office at 214 Beardshear. Retaliation against persons filing complaints for the redress of a grievance, or for assisting in an investigation pursuant to the filing of a complaint, shall be prohibited.

Administration of Iowa State University

The laws of the United States and of the State of Iowa provide for resident academic instruction, research, and extension education, and for the management of Iowa State University of Science and Technology. The University and two other state educational institutions of higher learning are governed by the State Board of Regents, composed of nine members nominated by the Governor of Iowa and confirmed by the Senate of Iowa. The immediate regulation and direction of the academic, research, and extension activities of the University are delegated by the Board of Regents to the president and faculty of the University. The Board appoints an executive secretary with over-all responsibility for the administration of the central office of the Board located in Des Moines.

State Board of Regents

Mrs. H. Rand Petersen, President
R. Wayne Richey, Executive Secretary

Terms expire June 30, 1981
Ray V. Bailey ..... Clarion
Mrs. H. Rand Petersen ..... Harlan
Donald H. Shaw ..... Davenport

Terms expire June 30, 1983
.....
Percy G. Harris, M.D. ..... Cedar Rapids
Peter J. Wenstrand ..... Essex

Terms expire June 30, 1985
S. J. Brownlee ..... Emmetsburg
Ann Jorgensen ..... Garrison
Arthur Neu ..... Carroll

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James H. Hilton, D.Sc., President Emeritus

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Wayne R. Moore, B.S., Vice President for Business and Finance

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Bernard O. Randol, B.B.A., C.P.A., Controller and Secretary

Graduate College

Daniel J. Zaffarano, Vice President for Research and Dean
Norman L. Jacobson, Associate Vice President for Research and Associate Dean
George G. Karas, Associate Dean
Martin J. Ulmer, Associate Dean

The Graduate College at Iowa State University is responsible for the quality of graduate education, for administering students' graduate programs and for promoting research support from various governmental, industrial, and private agencies.

Members of the graduate faculty have a dual role of teaching and research. All courses offered for major or minor credit are taught by graduate faculty members. Through an advisory committee system, they supervise individual programs of study which are specially designed for each graduate student's needs.

The graduate faculty includes the president, the vice-president for academic affairs, the dean and associate deans of the Graduate College, deans and associate deans of the other seven colleges, the dean of library services, and the directors and associate directors of research institutes as full members. Executive officers of departments and other members of the General Faculty may be elected to associate or full membership in recognition of accomplishments in their respective disciplines.

Graduate study was offered almost as soon as the University was founded, and the first graduate degree was conferred in 1877. Experimentation and research also started early, first in agriculture and shortly thereafter in home economics, engineering, science, and veterinary medicine. In 1913, a distinct graduate faculty was organized and an executive graduate committee appointed. In 1915, the graduate faculty held its first meeting and in 1916 it granted the first degree, Doctor of Philosophy.

Graduate education is vital to the quality of university teaching. The creative efforts of graduate faculty members and graduate students result in knowledge necessary to help society solve problems in educational, scientific, technological, and socio-economic areas. The Graduate College encourages educational exchange and contact with undergraduate areas of the University to promote improved teaching on both the undergraduate and graduate level. A part of this exchange is accomplished by books and technical articles which are made possible by graduate research.

The degrees Master of Arts, Master of Science, and Doctor of Philosophy are research oriented, although in certain fields the Master of Arts and the Master of Science degrees are also available without thesis. For those persons interested in advanced study directed more particularly toward meeting vocational or professional objectives, the degrees Master of Agriculture, Master of Architecture, Master of Community and Regional Planning, Master of Education, Master of Engineering, Master of Landscape Architecture, Master of Public Administration, and Specialist are offered.

Graduate Appointments

Graduate assistantships, fellowships, and certain special research grants have been established at Iowa State University for the encouragement of graduate work and the promotion of research. Such appointments and research opportunities are available through the various departments of instruction, the Agriculture and Home Economics Experiment Station, the Research Institute for Studies in Education, the Engineering Research Institute, the Home Economics Research Institute, the Sciences and Humanities Research Institute, the Veterinary Medical Research Institute, the Statistical Laboratory, the Computation Center, the Energy and Mineral Resources Research Institute, the Water Resources Research Institute, and the Office of the Vice President for Research.

A half-time graduate assistantship permits the holder to enroll for a maximum of 12 semester credits. Recipients of these assistantships are assessed fees at resident rates. Students who are graduates of a regionally accredited college or university in the United States or of a recognized institution in another country whose requirements for the bachelor's degree are substantially equivalent to those of Iowa State University, who graduated in the highest quartile of their respective classes and who present the requisite undergraduate or graduate preparation, may apply for these appointments. Students registered on a restricted or nondegree basis and those placed on academic probation are not eligible for assistantship appointment. Further information may be obtained by writing to the appropriate department head.

The satisfactory completion of one appointment, plus satisfactory academic performance, will ordinarily make a student eligible for reappointment. After a period of 5 years of full time study for the master's degree or 7 years for the doctorate, the student will not normally be continued on assistantship support.

Fellowships and traineeships supported by agencies of the federal government are sometimes available. Applicants for these awards must present evidence of superior scholarship. Further information may be secured by writing to the dean of the Graduate College.

MASUA Traveling Scholar Program

As a member of the Mid-America State Universities Association, Iowa State University participates in the MASUA Traveling Scholar Program. Universities cooperating include Iowa State University; University of Kansas; Kansas State University; University of Missouri at Columbia, Kansas City, Rolla and St. Louis; University of Nebraska; University of Oklahoma; and Oklahoma State University.

The MASUA Traveling Scholar Program is designed to provide breadth and depth in the opportunities for graduate study offered at MASUA universities by permitting advanced graduate students to study at another MASUA university where they may utilize unique facilities or specializations.

Graduate students at MASUA universities are eligible to participate in this program for a minimum of one term of enrollment. The student's major adviser initiates the proposal for the student's participation by contacting the professor at another MASUA university where the student wishes to study. The graduate dean at each university involved must concur in proposed participation. During the time of participation, the student will register for research or special topics credit for the appropriate number of hours and pay fees at the home university. Graduate students chosen to participate in the program will be provided $100 for travel and a stipend of $50 monthly for a minimum of three months (payable from MASUA funds upon return to the home institution). Additional information concerning the MASUA Traveling Scholarship Program is available at the Graduate Office.

Postdoctoral Study

Opportunities are provided for postdoctoral study through the extensive research programs of the University. Inquiries should be directed to the appropriate department, institute, or to the dean of the Graduate College.

Graduate Study by Members of the Staff

Any full-time member of the research, instructional, or extension staffs of the rank of instructor, subject to the approval of the head of his or her department or section, may carry not more than 6 semester credits of graduate work per semester, provided such does not interfere with other duties. This privilege may be extended to members of the research, instructional, or extension staffs of the rank of assistant professor upon approval of the dean of the employee's college and the dean of the Graduate College.

Staff members holding the rank of professor or associate professor cannot become candidates for degrees from this institution.

Admission

Admission to the Graduate College may be granted to a graduate of an institution in the United States which is accredited by a recognized regional association or to a graduate of a recognized institution in another country whose requirements for the bachelor's degree are substantially equivalent to those of Iowa State University. For information concerning graduate study in a particular academic discipline, a prospective student is invited to correspond with the head of the department in which he or she wishes to study.

Application forms are available from the Office of Admissions, 7 Beardshear Hall. These forms, together with official transcripts and statement of quartile rank, should be forwarded to the Office of Admissions at least one month prior to the opening of the semester when the student wishes to matriculate. An application fee of $10 is charged each applicant formally applying for admission to the Graduate College. If the undergraduate degree is from Iowa State University or if the student is applying for nondegree admission, no application fee is assessed.

Graduate Record Examination. The Graduate Record Examination (GRE) is not a university-wide requirement for all applicants. However, some departments require or recommend submission of GRE scores; individual departmental statements appearing later in this catalog should be consulted for this information.

Full Admission. An applicant who is a graduate of a regionally accredited institution in the United States or of a recognized institution in another country whose requirements for the bachelor's degree are substantially equivalent to those of Iowa State University, and who ranks in the upper one-half of his or her class, may be admitted to the Graduate College, if recommended by the department and approved by the dean of the Graduate College. Admission does not constitute acceptance as a candidate for a degree.

Provisional Admission. An applicant who is a graduate of a regionally accredited college or university in the United States or of a recognized institution in another country, whose requirements for the bachelor's degree are substantially equivalent to those at Iowa State University, and who ranks in the upper one-half of his/her class, but who has certain background deficiencies to remedy, may be admitted to the Graduate College on provisional admission if recommended by the department and approved by the dean of the Graduate College. Students accepted on provisional admission are eligible to apply for graduate assistantships. Transfer from provisional admission to full admission requires recommendation of the major professor and approval by the Graduate College.

Restricted Admission may be granted to persons who are graduates of regionally accredited universities or colleges of the United States but who do not rank in the upper one-half of their class, and to graduates of recognized foreign institutions. This status requires the recommendation of the major department and approval of the dean of the Graduate College. Transfer from restricted to full admission usually requires completion of at least 10 semester hours of graduate level courses with a grade average of B or above. The recommendation must be submitted by the student's major professor and approved by the dean of the Graduate College.

Nondegree Admission. A graduate of a regionally accredited university or college in the United States may be granted nondegree admission: (1) to take course work for subsequent transfer to other institutions; (2) to enroll occasionally in off-campus graduate courses; or (3) to take graduate courses without pursuing an advanced degree program.

Transfer from nondegree admission to full admission requires submission of complete academic records, recommendation by the department head and the approval of the graduate dean, and payment of an application fee of $10 by those who do not have an undergraduate degree from Iowa State University.

For those students admitted to the Graduate College for nondegree study, no more than 9 semester hours of graduate credit earned under the non-degree option may be applied if the student later chooses to undertake a degree option. The student's advisory committee will recommend which courses, if any, taken on a nondegree basis may be included in the program of study.

Medical Examination

New students will be sent a medical history form with their letter of admission. This form must be completed and on file at the Student Health Service before a student can be treated by a physican there. All records are confidential. Student records are not available without the student's permission. A copy of the record may be sent to a physician of the student's choice.

English Requirement

The status of all graduate students whose native language is English is determined at the time of admission. Students who fall into one of the following categories have fulfilled the English requirement: 1) have completed an undergraduate English composition sequence with a B average or better; 2) have passed, as an undergraduate, an English examination which tests the ability to communicate in writing (similar to the ISU Graduate English Examination); and 3) have written in the English language a master's thesis which has been accepted by a regionally accredited college or university; or 4) have passed the Graduate English Examination as specified by the major department. Individual departments may establish more stringent requirements. The departments of Chemistry, Earth Sciences, Physical Education and Veterinary Pathology require their students to satisfy the requirement by taking the Graduate English Examination.

Students (except those admitted on a nondegree basis) who are required to take the Graduate English Examination should do so before completing 12 credit hours of graduate work at Iowa State University.

Foreign Students

An applicant who is a graduate of a recognized foreign institution is subject to the same criteria for admission as a graduate from an institution in the United States and may be recommended for the same admission categories described above. The *admission* deadline for international students is one month prior to the first day of classes for each semester.

A graduate student whose native language is not English must take a special English placement examination administered by the Department of English in lieu of the standard qualifying examination.

Students registered on a restricted or nondegree admission basis and those placed on probation are not eligible for assistantship appointment.

Foreign students are required to carry adequate health and accident insurance while in residence.

Registration

Planning Graduate Study. Scholastic competence, independence and maturity of thought should have dominance over other objectives of graduate study. Students must accept responsibility for their own education and should recognize that excessive emphasis on course work will not leave time to explore and master aspects of learning which will give them confidence in their own judgments. As soon as possible, in conference with the head of the department, the student should select a major professor and advisory committee and in consultation with them outline a program of study.

Residence Registration. Classification in courses carrying full graduate credit is limited to a maximum of 15 credits per semester: Schedules for graduate assistants on one-half time appointments are limited to a maximum of 12 credits. For full-time staff members, the limit is 6 credits.

Even though course and residence requirements have been met graduate students must register in any semester in which the facilities of the institution or staff time are being used, including library borrowing privileges and preparation of thesis or dissertation, or preparation for examination. The student must be registered during the semester in which the preliminary and final examinations are held.

Interim Registration. Registration for special work between semesters and during certain vacation periods cannot exceed 1 credit for each week that the student is in residence.

"In Absentia" Registration. Graduate work by correspondence is not permitted, nor is it accepted in transfer. In absentia registration is restricted to thesis preparation after completion of research or for research under special conditions. The total credit thus obtained cannot be used to reduce residence requirements.

Extension and Off-campus Registration. Many departments offer off-campus classes taught by members of the university graduate staff. For this puporse special arrangements are made for the necessary library and laboratory resources so that the classes are equivalent to those taught on campus.

Continuing Registration Policy. Graduate students who pass the oral preliminary examination for the Ph.D. degree and leave the Ames campus for one or more semesters before receiving their degrees must pay an "R" fee each semester for maintenance of their records each semester they are absent and are not using university facilities or faculty time. This fee must be continued each semester excluding summer term.

Students who have passed the preliminary oral examination and are using university facilities and/or faculty time must register each semester for an appropriate number of credit hours and must pay resident or nonresident fees, in accordance with their residency status, regardless of being primarily on campus or off campus.

Auditing. Courses may be audited upon recommendation of the student's major professor. Each audited course will reduce the permitted credit load by one, but fees will be assessed on the basis of the credit hours of the course.

Special Regulations for Students in Veterinary Medicine. Specially qualified advanced students in veterinary medicine may request permission from the dean of the College of Veterinary Medicine and the dean of the Graduate College to pursue work coincidentally toward the degrees Master of Science or Doctor of Philosophy and Doctor of Veterinary Medicine.

To participate in such a concurrent program, a student must be admitted to the Graduate College and an advisory committee must be appointed according to the usual procedures. A program of study must be submitted to the Graduate College and the College of Veterinary Medicine for approval.

Degree Requirements

A *Graduate Student Handbook* is available in the Graduate Office. Each new graduate student is urged to obtain a copy. A *Graduate Faculty Handbook,* listing policies and procedures of the Graduate College, is also available to all staff members and may be obtained at the Graduate Office.

Probation. To remain in good standing, a student must maintain an average of B on all work taken in the Graduate College (exclusive of research credits). A student may be placed on probation for failure to meet scholastic requirements. Removal from probation is accomplished upon specific recommendation from the student's major professor to the Graduate College. Students will not be admitted to candidacy while on probation. Generally registration beyond the second semester will be refused to a student whose quality of work is unsatisfactory.

Time Limit. It is expected that work for the master's degree shall be completed within five years. A student beginning a Ph.D. degree program at Iowa State with a master's degree is expected to complete the Ph.D. within five years, while a student beginning a Ph.D. degree program without the master's degree is expected to complete the program within seven years. In special circumstances the student's advisory committee may recommend that the graduate dean extend these degree time limits. Cases in which the student leaves Iowa State during his or her graduate career and later returns are dealt with individually by the student's advisory committee and the Graduate Office.

Master of Science and Master of Arts

A student on full admission becomes eligible for candidacy after completing one semester's work with a B average. General requirements for the degree are as follows:

Appointment of the Student's Advisory Committee. As soon as praticable after the student enrolls in the Graduate College, the department head or chairman shall recommend to the dean of the Graduate College a committee of the graduate faculty to be in charge of the student's work.

This committee shall consist of at least three members of the graduate faculty, one of whom must be from a department other than that in which the student is enrolled. At least one member of the committee should be a full member of the graduate faculty. An associate member of the graduate faculty may serve as a major professor for a master's degree candidate. A faculty member holding a joint appointment may not serve as an "outside the department" member on a committee if the student's major is in either of the departments represented in the joint appointment.

Program of Study. A program of study, developed by the student and major professor in consultation with the program of study committee should be submitted for approval by the end of the second semester in residence.

Residence. There is no on-campus residence requirement for the master's degree.

Credits. At least 30 credits of acceptable graduate work must be completed, not less than 22 of which must be earned from this institution.

Any transfer of credits from another institution must be recommended in the program of study by the student's program of study committee. Graduate credit will be approved for transfer only if it is of B grade or better.

Major. The exact number of credits in a major is not prescribed. To obtain the specialization which is considered essential for an advanced degree, approximately two-thirds of the work should be devoted to the major field, but this is not necessarily restricted to one department. A formal minor may be declared but will require approval by the minor department.

A graduate student may not change from one department to another without written permission from the heads of departments involved, and approval of the dean of the Graduate College.

Foreign Languages. There is no uniform language requirement for the Graduate College. Please see the departmental descriptions in this catalog for specific departmental requirements.

For those departments wishing to utilize them and for students interested in transferring a foreign language test score elsewhere, the University offers the standardized examinations provided by Educational Testing Service.

For students whose native language is not English, the ability to communicate adequately in English (certified by the Department of English) may be acceptable as a substitute for the reading knowledge of one foreign language. This option will apply only when specifically recommended by the student's program of study committee.

The foreign language requirements, where applicable, must be met before the semester in which the student will receive the degree.

Application for Graduation. Application for graduation must be made by midterm of the semester preceding the semester in which the student expects to receive the degree. This requires the presentation of an approved diploma slip to the Office of the Graduate Dean.

Thesis. A thesis is required in all areas in which the M.S. or M.A. is granted, except where specific provision is made for a nonthesis degree program. Joint authorship is not permitted. Copies of the completed thesis must be in the hands of the examining committee and the Thesis Office for approval two weeks prior to the date fixed for the final examination. After the final examination, two unbound approved copies of the thesis shall be deposited with the Thesis Office, 213 Beardshear Hall. These copies of the thesis must be deposited not less than two weeks prior to commencement. A charge of $30 will be made to cover library costs and title publication in *Iowa State Journal of Research.*

The student should consult *The Graduate College Thesis Manual* for instructions about thesis preparation and time schedules.

Final Examination. After all other requirements have been met, the final examination shall be taken over all graduate work, including the thesis where applicable. It will be oral, but may be written in part if specified by the committee in charge.

Graduation Approval Slip. This slip is prepared by the Office of Student Records about two weeks before the end of a semester. Candidates wishing to secure this form at any earlier date should file a request with the Graduate Office at least three days prior to the time the form is needed.

Master of Science and Master of Arts — Nonthesis

In certain departments a nonthesis degree program may be undertaken. This will require satisfactory completion of at least 30 credit hours of acceptable work (not including research credit) and satisfactory completion of a comprehensive examination. Every nonthesis master's program, however, must present substantial evidence of individual accomplishment which may vary from a special report, for example, or an annotated bibliography to a project in research, design, or other creative endeavor. A minimum of three hours of such independent work is required on every program of study for a nonthesis master's degree. This element of creative independent study shall be explicitly identified on the program of study. Detailed requirements may vary with fields. Reference should be made to the departmental descriptions in this catalog.

Master of Agriculture

The major in professional agriculture is an off-campus, non-thesis program leading to the degree Master of Agriculture. It is available to students wishing to pursue graduate study in agriculture without taking formal course work on campus. The program is considered to be a terminal master's degree. Students are required to take a minimum of two courses in each of three disciplines and complete 24 semester credits of formal course work. Courses are offered in Agricultural Mechanization, Agronomy, Animal Science and Economics. A minimum of four credits of creative component experience is required. Four workshops of one credit each are also required

Master of Architecture

The Department of Architecture offers several programs leading to the degree Master of Architecture, a professional degree. Beyond the degree Bachelor of Agriculture, a minimum of 30 graduate credits is required. Beyond the degrees B.A. or B.S. in architecture or environmental design, a minimum of 60 credits is required. For students with other baccalaureate degrees, a program of more than 60 credits will be tailored to each student's experience, training, and education. For programs of 60 credits or more, 40 of these credits must be graduate credits.

Master of Community and Regional Planning

The degree Master of Community and Regional Planning requires 52 semester hour credits, including a 9 credit thesis.

Graduate Courses Taken by Seniors. Certain graduate level courses listed in the *General Catalog* may be taken for graduate credit by undergraduate seniors at Iowa State University.

If a student is admitted for graduate study at Iowa State University, the advisory committee at the time the program of study is submitted may request approval from the graduate dean that up to 9 semester hours of such credit be applied toward meeting advanced degree requirements. Credits earned in these courses must be in addition to those used to meet requirements for the bachelor's degree.

Master of Education

For the degree master of education, a minimum of 30 credits of graduate level courses will be required. A creative component is required in which the student demonstrates an ability to perform creative, independent study.

Master of Engineering

The academic standards and the general level of attainment are the same for the Master of Engineering and Master of Science degrees. Master of Engineering programs are offered to meet the needs for professionally oriented programs on campus, and for off-campus professionally oriented programs at locations with adequate library and laboratory facilities.

An appropriate number of credit hours in design, laboratory work, computation or independent study is required as evidence of individual accomplishment.

Of the minimum credit requirement of 30, 22 credits must be received from Iowa State University.

Master of Landscape Architecture

The degree Master of Landscape Architecture requires a minimum of 40 graduate credits and the satisfactory completion of a thesis or a terminal project.

Master of Public Administration

This is a professional degree program designed to provide training necessary for an administrator in a public or quasi-public bureaucracy. A minimum of 39 semester credit hours is required in six subject areas. Either an internship in a governmental unit or a thesis is required.

Specialist

This degree is a post-master's degree in school psychology requiring 60 hours of work beyond the baccalaureate. It requires a thesis equivalent to a master's thesis, and an internship in the public schools of not less than 600 clock hours.

Doctor of Philosophy

The degree Doctor of Philosophy is strongly research oriented. The primary requirements for the degree are: 1) high attainment and proficiency of the candidate in his or her chosen field, (2) development of a dissertation which is a significant contribution to knowledge and which shows independent and creative thought and work, and (3) successful passing of detailed examinations over the field of the candidate's major work, with a satisfactory showing of preparation in related courses.

Appointment of the Student's Program of Study Committee. As soon as practical after the student enrolls in the Graduate College, the department head or chair shall recommend to the dean of the Graduate College a committee of the graduate faculty to be in charge of the student's graduate program. This committee shall consist of at least five members of the graduate faculty, three of whom must be full members. At least two committee members must be outside the declared major or area of specialization, and at least one of these must be outside the major department. A faculty member holding a joint appointment may not serve as an "outside the department" member on a committee if the student's major is in either of the departments represented in the joint appointment. An associate member of the graduate faculty may not serve as a major professor of a doctoral program but may co-chair a doctoral committee.

Program of Study. A program of study should be developed by the student in consultation with his or her major professor and committee. This should be submitted for approval by the end of the second semester in residence.

Residence. A minimum of 72 graduate credits must be earned for a Ph.D. degree. At least 36 credits including all dissertation research credits must be earned under the supervision of the student's program of study committee. Graduate credits of B grade or better earned at another institution may be transferred at the discretion of the program of study committee and the approval of the department and Graduate College. Transfer of S and "pass" grades may be accepted for research only when such grades can be documented as being B grade or better. Responsibility for submitting such documentation to the Graduate College rests with the student's program of study committee.

At least 24 credits must be earned during two consecutive semesters while in residence at the University.

Major and Minor. A major is the area of study or academic concentration in which a student chooses to qualify for the award of a graduate degree. Majors are listed for departments and interdepartmental programs in the *Courses and Programs* section of the catalog.

To avoid overspecialization, a significant body of pertinent course work must be taken outside of the major field. The work outside the major field should amount to approximately 12 hours of applicable graduate credit as required by the student's committee.

Opportunities also exist for majoring in more than one area of study (co-major or joint-major programs).

Courses for minor credit are listed by departments or interdepartmental programs. (See *Courses and Programs.)* Formal minors may be declared, in which case the student must meet certain minimum requirements established by the department administering the minor.

Foreign Languages. The Graduate College has no uniform requirements. Foreign language requirements for those departments having them are specified in the individual department descriptions in the *Courses and Programs* section of this catalog.

For those departments wishing to use them and for students interested in transferring a foreign language test score elsewhere, the University offers the standardized examinations provided by the Educational Testing Service.

For students whose native language is not English, the ability to communicate adequately in English (certified by the Department of English) may be acceptable as a substitute for the reading knowledge of one foreign language. This option will apply only when specifically recommended by the student's program of study committee.

The foreign language requirement, when applicable, may be fulfilled at any time, but not less than six months prior to the final examination.

Preliminary Examination. The student must pass satisfactorily a preliminary examination before being granted advancement to candidacy for the degree. This examination is comprehensive and should not be restricted only to the content of graduate courses. It usually has two parts: a written examination followed by an oral examination. The oral examination is mandatory, and all members of the student's doctoral committee (or approved substitutes) must be present. The preliminary examination is usually given before all course work has been completed, and must be passed at least six months before the final examination. Exceptions to this rule will be made only upon special recommendation of the student's committee and approval of the graduate dean.

Diploma Slip. A diploma slip must be filled out and returned by mid-term of the semester preceding the semester in which the student expects to receive the degree.

Dissertation. A doctoral dissertation shall be completed on some topic connected with the major field. To be acceptable, it must constitute a significant contribution to knowledge. Joint authorship is not permitted.

Copies of the completed dissertation must be in the hands of the examining committee and the Thesis Office for approval two weeks prior to the date fixed for the final examination. After the examination, and at least two weeks prior to commencement, two complete and approved copies of the dissertation shall be deposited with the Thesis Office, 213 Beardshear Hall.

At the same time the dissertation is deposited, two typewritten copies of an abstract which meet the requirements as set forth in *The Graduate College Thesis Manual* must also be filed with the Thesis Office, 213 Beardshear. A charge of $60 will be made to cover costs, microfilming of the dissertation, and publication of a 600-word abstract in *Dissertation Abstracts*. The abstract should cover the entire dissertation and should not be considered as excluding publication of a journal article.

Final Examination. A final examination shall be taken after submission of the dissertation and the completion of all other work prescribed for the degree. This examination shall be oral; it may be both written and oral if specified by the student's committee. It is intended principally as a defense of the dissertation.

Graduation Approval Slip. These slips are prepared by the Office of Student Records about two weeks prior to the end of a semester. Candidates wishing to secure this form at any earlier date should file a request with the Office of the Graduate Dean at least three days prior to the time the form is needed.

Summary of Graduate Degrees, Majors and Areas of Specialization*

Aerospace Engineering — M. Eng., M.S., Ph.D. — Aerospace Engineering.

Agricultural Education — M.S., Ph.D. — Agricultural Education.

Agricultural Engineering — M. Eng., M.S., Ph.D. — Agricultural Engineering, Agricultural Mechanization (minor only), *Soil and Water Resources, Agricultural Power and Machinery, Electric Power and Processing, Agricultural Structures and Environment, Animal Waste Management.*

Agronomy — M.S., Ph.D. — Agricultural Climatology, Crop Production and Physiology, Plant Breeding and Cytogenetics, Soil Chemistry, Soil Fertility, Soil Management, Soil Microbiology and Biochemistry, Soil Morphology and Genesis, Soil Physics.

Animal Ecology — M.S., Ph.D. — Animal Ecology, *Animal Behavior, Ecology, Taxonomy, Limnology;* Fisheries Biology, *Animal Behavior, Ecology, Limnology, Taxonomy;* Wildlife Biology, *Animal Behavior, Ecology, Taxonomy, Limnology.*

Animal Science — M.S., Ph.D. — Animal Breeding, Animal Nutrition, Animal Production (M.S. only), Meat Science, Muscle Biology, Nutritional Physiology, Physiology of Reproduction, Poultry Nutrition, Poultry Products Technology.

Anthropology — See Sociology.

Architecture — M. Arch. — Architecture.

Art and Design — M.A. — Art and Design, *Advertising Design, Art Education, Craft Design, Interior Design.*

Biochemistry and Biophysics — M.S., Ph.D. — Biochemistry, Biophysics.

Biomedical Engineering (Interdepartmental Program) — M.S., Ph.D. — Biomedical Engineering.

Botany — M.S., Ph.D. — Botany, *Aquatic Plant Biology, Cytology, Ecology, Economic Botany, Morphology, Mycology, Physiology, Taxonomy.*

Chemical Engineering — M. Eng., M.S., Ph.D., — Chemical Engineering.

Chemistry — M.S., Ph.D., — Analytical Chemistry, Chemistry. *Inorganic-Organic* (Ph.D. only), *Physical-Inorganic* (Ph.D. only), *Analytical-Physical, Organic-Analytical* (Ph.D. only), Inorganic Chemistry (Ph.D. only), Organic Chemistry, Physical Chemistry.

Child Development — M.S., Ph.D. — Child Development.

Civil Engineering — M.S., Ph.D. — Civil Engineering (M.S. only), Geodesy and Photogrammetry (M.S. only), Municipal Engineering (M.S. only), Sanitary Engineering, Geotechnical Engineering, Structural Engineering, Transportation Engineering.

*Areas of specialization are shown in italics.

Community and Regional Planning — M.C.R.P. — Community and Regional Planning.

Computer Science — M.S., Ph.D. — Computer Science.

Earth Sciences — M.S., Ph.D. — Earth Science, Geology, Meteorology.

Economics — M.S., Ph.D. — Agricultural Economics, Economics.

Education — See Professional Studies.

Electrical Engineering — M. Eng., M.S., Ph.D. — Electrical Engineering, *Electromagnetics* (Ph.D. only), *Computer Engineering* (Ph.D. only), *Control Systems* (Ph.D. only), *Electric Power* (Ph.D. only).

Energy Systems Engineering — Interdepartmental minor only.

Engineering Science and Mechanics — M. Eng., M.S., Ph.D. — Engineering Mechanics.

English — M.A. — English.

Entomology — M.S., Ph.D. Entomology, *Behavior, Biological Control, Ecology, Economic Entomology, Medical Entomology, Host Plant Resistance, Morphology, Pathology, Pest Management, Physiology, Systematics, Insecticide Toxicology.*

Family Environment — M.S., Ph.D. (joint major) — Family Environment.

Food and Nutrition — M.S., Ph.D. — Food and Nutrition (M.S. only), Food Science, Nutrition.

Food Technology — M.S., Ph.D. — Food Technology, Meat Science (joint major).

Forestry — M.S., Ph.D. — Forestry, *Administration and Management* (M.S. only), *Biology* (M.S. only), *Biometry, Economics and Marketing* (M.S. only), *Wood Science* (M.S. only), *Forest Economics* (Ph.D. only), *Biology — Wood Science* (Ph.D. only).

General Graduate Studies (Interdepartmental Program) — M.A., M.S., — General Graduate Studies, *Arts and Humanities, Biological Sciences, International Development Studies, Physical Sciences, Social Sciences.*

Genetics — M.S., Ph.D. — Genetics.

Gerontology — Interdepartmental minor only.

History — M.A., Ph.D. — History (M.A. only), History of Technology and Science.

Home Economics Education — M.Ed., M.S., Ph.D. — Home Economics Education.

Horticulture — M.S., Ph.D. — Horticulture.

Housing — Interdepartmental minor only.

Immunobiology (Interdepartmental Program) — M.S., Ph.D. — Immunobiology.

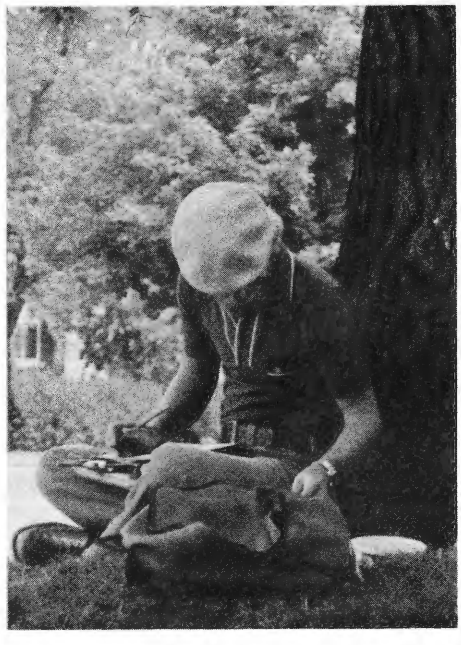
Industrial Administrative Sciences (Interdepartmental Program) — M.S. — Industrial Administrative Sciences.

Industrial Education — M.Ed., M.S., Ph.D. — Industrial Education, *Industrial Arts, Industrial Vocational-Technical Education, Occupational and Traffic Safety Education.*

Industrial Engineering — M. Eng., M.S., Ph.D. — Engineering Valuation, Industrial Engineering (M. Eng., M.S. only), *Operations Research* (co-specialization, M.S. only).

Industrial Relations (Interdepartmental Program) — M.S. — Industrial Relations.

Institution Management — M.S., Ph.D. (joint major) — Institution Management.



Journalism and Mass Communication — M.S. — Journalism and Mass Communication.

Landscape Architecture — M.L.A. — Landscape Architecture.

Materials Science and Engineering — M.Eng., M.S., Ph.D. — Materials Science and Engineering (M.Eng. only), Ceramic Engineering, Metallurgy, *Chemical Metallurgy, Mechanical Metallurgy, Physical Metallurgy.*

Mathematics — M.S., Ph.D. — Applied Mathematics, Mathematics.

Mechanical Engineering — M.S., Ph.D. — Mechanical Engineering.

Microbiology — M.S., Ph.D. — Microbiology; *Applied, Food, Medical, Systematic Microbiology; Immunology; Microbial Ecology, Genetics, Morphology, Physiology; Virology.*

Molecular, Cellular, and Developmental Biology — Interdepartmental major only

Nuclear Engineering — M. Eng., M.S., Ph.D., — Nuclear Engineering.

Physical Education — M.S. — Physical Education.

Physics — M.S., Ph.D. — Astrophysics, High Energy Physics, Nuclear Physics, Physics, Solid State Physics.

Plant Pathology, Seed and Weed Sciences — M.S., Ph.D. — Plant Pathology, *Seed Science, Weed Science.*

Political Science — M.A., M.P.A. — Political Science, Public Administration.

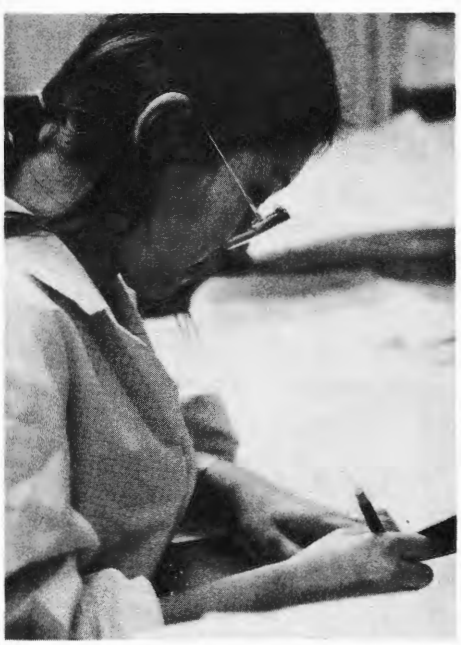
Professional Agriculture (Interdepartmental Program) — M.Agric. — Professional Agriculture.

Professional Studies in Education — M.Ed., M.S., Ph.D. — Education; *Adult and Extension Education; Curriculum and Instructional Media; Educational Administration; Elementary Education* (M.S. only); *Counselor Education; Higher Education; History, Philosophy, and Comparative Education; Learning Disabilities* (M.S. only); *Research and Evaluation.*

Psychology — M.S., Sp., Ph.D. — Psychology, School Psychology (Sp. only).

Sociology and Anthropology — M.A., M.S., Ph.D. — Rural Sociology, Sociology, *Anthropology* (M.A. only).

Statistics — M.S., Ph.D. — Statistics, *Applied Statistics, Experimental Design, Statistical Methods, Operations Research (co-specialization, M.S. only), Probability, Statistical Computing, Statistical Theory, Survey Sampling.*



Technology and Social Change — Interdepartmental minor only.

Textiles and Clothing — M.S. — Textiles and Clothing.

Transportation Planning — Interdepartmental major only.

Veterinary Anatomy — M.S., Ph.D. — Veterinary Anatomy.

Veterinary Clinical Sciences — M.S. — Veterinary Clinical Science, *Veterinary Radiology, Theriogenology, Veterinary Surgery, Veterinary Medicine.*

Veterinary Microbiology and Preventive Medicine — M.S., Ph.D. — Veterinary Microbiology, Veterinary Preventive Medicine (M.S. only).

Veterinary Pathology — M.S., Ph.D. — Veterinary Pathology, *Veterinary Parasitology, Veterinary Toxicology.*

Veterinary Physiology and Pharmacology — M.S., Ph.D. — Veterinary Physiology, *Pharmacology.*

Water Resources — Interdepartmental major only.

Zoology — M.S., Ph.D. — Zoology; *Animal Behavior; Cellular Biology; Comparative Physiology; Ecology; Endocrinology; Immunobiology; Cellular, Molecular and Developmental Biology; Neurobiology; Parasitology; Physiology.*

Interdepartmental Offerings and Cooperating Departments

Interdepartmental Programs

Biomedical Engineering — College of Engineering; College of Veterinary Medicine.

General Graduate Studies — all departments offering graduate courses.

Immunobiology — Agronomy, Animal Science, Biochemistry and Biophysics, Food and Nutrition, Genetics, Microbiology, Veterinary Microbiology and Preventive Medicine, Veterinary Pathology, and Zoology.

Industrial Administrative Sciences — Business Administration, Economics, Industrial Engineering, Statistics.

Industrial Relations — Economics, Industrial Engineering, Political Science, Psychology, Sociology.

Professional Agriculture — Agricultural Engineering, Agronomy, Animal Science, Economics.

Interdepartmental Majors

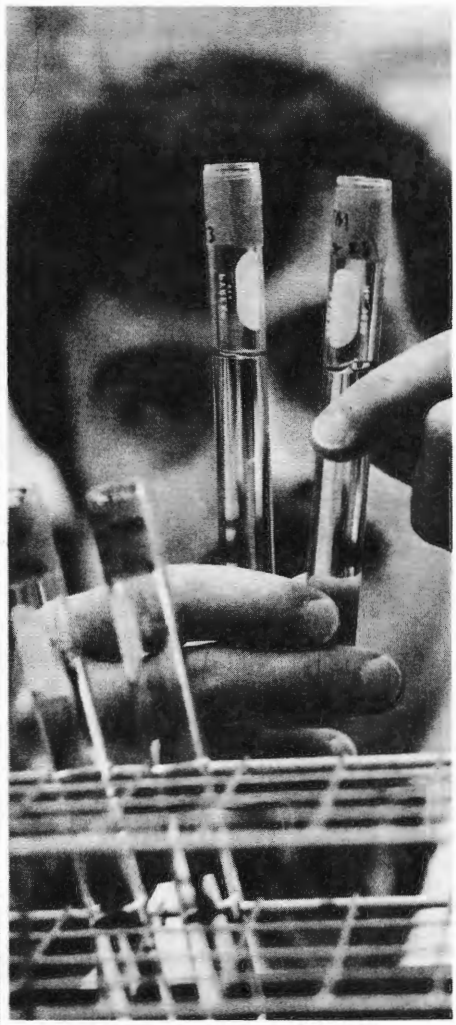
Molecular, Cellular, and Developmental Biology — Agronomy, Animal Science, Biochemistry and Biophysics, Botany, Food Technology, Genetics, Microbiology, and Zoology.

Transportation Planning — Business Administration, Civil Engineering, Community and Regional Planning, Economics, Industrial Engineering, Political Science, and Sociology.

Water Resources — Agricultural Engineering, Agronomy, Animal Ecology, Botany, Chemical Engineering, Civil Engineering, Earth Sciences, Economics, Family Environment, Food and Nutrition, Food Technology, Forestry, Horticulture, Industrial Engineering, Microbiology, Nuclear Engineering, Political Science, and Sociology.

Interdepartmental Minors

Energy Systems Engineering — Aerospace Engineering, Agricultural Engineering, Architecture, Chemical Engineering, Civil Engineering, Electrical Engineering, Engineering Science and Mechanics, Industrial Engineering, Materials Science and Engineering, Mechanical Engineering, and Nuclear Engineering.



Gerontology — Architecture, Biochemistry and Biophysics, Business Administration, Economics, Family Environment, Food and Nutrition, Home Economics Education, Political Science, Professional Studies in Education, Psychology, Sociology and Anthropology, Speech, Textiles and Clothing.

Housing — Architecture, Art and Design, Community and Regional Planning, Family Environment, Landscape Architecture.

Technology and Social Change — Aerospace Engineering, Agricultural Engineering, Agronomy, Animal Science, Chemical Engineering, Chemistry, Civil Engineering, Community and Regional Planning, Computer Science, Earth Sciences, Economics, Electrical Engineering, English, Family Environment, Food and Nutrition, History, Industrial Education, Industrial Engineering, Journalism and Mass Communication, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, Physics, Philosophy, Political Science, Professional Studies in Education, Sociology and Anthropology, Textiles and Clothing.

Fees and Expenses

(Fees and tuition are subject to change without notice.)

A registration fee is charged all students of the University. A full registration fee covers most laboratory fees, access to student health facilities, use of the Library, membership in the Memorial Union, and a number of student activities. In certain courses involving special expenses, an additional fee may be charged. These fees are indicated in the course description of the specific courses involved.

Students who are not residents of Iowa pay an additional tuition fee each semester. This tuition fee is assessed in accordance with regulations of the State Board of Regents which are found in the General Catalog under *Admission and Records*.

All fees and expenses listed in this catalog are effective as of fall semester 1981. They are subject to change without notice.

Fee Schedule

	Resident	Nonresident
Per Semester		
Graduate		
(9 or more hours)...	$ 540	$1243

Fees for students enrolled for less than a full course load are given below. There is a minimum 2-hour fee for all students. Audits and zero credit courses are assessed on contact hours and there is a maximum charge for zero credit courses of 3 hours. R credits are assessed as one credit only if no other credits are taken. The continuing registration for graduate students is $80. If the total number of credits includes .5 credit, such as 6.5, fees are assessed as the next larger whole number of credits. Therefore 6.5 credit hours would be assessed as 7 credit hours.

Summer session fees are charged per credit hour as indicated in the hourly fee schedule, except that nonresidence students taking 2 hours or less are assessed at the resident rate.

Hourly Fee Schedule

No. of Hours	Graduate Res.	Graduate Nonres.
1	$120	$120*
2	120	120*
3	180	180*
4	240	240*
5	300	700
6	360	840
7	420	980
8	480	1120
9	540	1243

*Nonresident students taking 4 hours or less fall and spring and 2 hours or less summer are assessed at the resident rate.

Private Music Instruction

University students, per semester

1 lesson per week, ½ hour	$ 50
1 lesson per week, 1 hour	80

Nonuniversity students, per semester

1 lesson per week, ½ hour	$ 90
1 lesson per week, 1 hour	160

Special Students and Noncollegiate Students

Special students and noncollegiate students pay the same fees as undergraduates.

Application Fee

A fee of $10 must accompany the application for admission and is nonrefundable except in the case of residents of Iowa who are denied admission. This fee will not apply to special students or workshop applicants.

Late Registration Fee

A fee of $5 for the first day and $1 per day thereafter is charged to those who do not complete registration during the regular registration period. Maximum charge for late registration is $10.

Reinstatement Fee

Students receiving college approval to be reinstated after having been dropped for nonpayment of fees must pay a $10 reinstatement fee in addition to all other fees due.

Activity Fee

The activity fee for undergraduates and graduate students taking courses on campus is included in the general registration fee. Fees for courses taken off campus do not include the activity fee. Off-campus students may pay $25 per semester which allows them to pay student admission rates to concerts, lectures, debates, and athletic events.

Fee Refund for Cancellation of Registration

For those who withdraw during the first week, a 100 percent refund will be made. For those who withdraw after the first week, $80 will be retained and the remainder refunded according to the following schedule:

75 percent if withdrawal is during the second week.
50 percent if withdrawal is during the third week.
25 percent if withdrawal is during the fourth week.
No refund for a withdrawal after the end of the fourth week.

Fee refund for students who drop into light classification or reduce overload:

90 percent if change is made during first week.
75 percent if change is made during second week.
50 percent if change is made during third week.
25 percent if change is made during the fourth week.
No refund after the fourth week.

For the refund policy for off campus courses, contact the Office of Continuing Education.

Change of Classification Fee

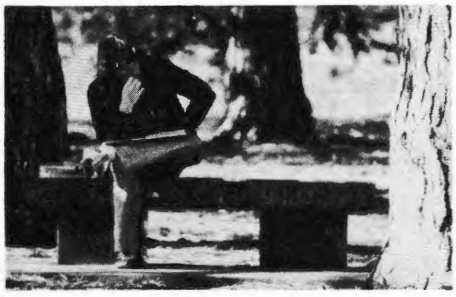
Starting the 6th day of classes a $5 fee is charged for course drops, additions, and section changes. Changes approved by the classification office at the same time are charged a single fee.

Workshops on Campus

Graduate and undergraduate students enrolled in 1-credit workshops on campus pay $80 tuition.

Off Campus Fees

For off-campus fees, contact the Office of Continuing Education.



Graduate Student Housing

Director: Charles F. Frederiksen, M.S.

Assistant Directors: Carlton T. Moen (University Student Apartments), Ph.D.; Gary G. Schwartz (Union Drive), M.A.; Virginia C. Arthur (Towers), M.A.; James F. Day (Richardson Court), M.Ed.; Thomas E. Walsh (Food Service), M.S.

Coordinator, Personnel Services: Robert J. Benson, M.S.

Manager, Administrative Services: L. R. McFarlin, B.C.S.

Manager, Food Stores: Robert Greiner, B.S.

Manager, Single Housing Maintenance: Donald D. Schoof

Coordinators of Residence Life: Ann Coppernoll, M.A.; Sally Kotval, M.A.; Glenn Buger, M.Ed.; William Zeller, M.S.; Anne Williams, M.Ed.; Delores Rice, M.A.; Patricia Robinson, M.A.; Donald Whalen, M.A.

The University provides housing facilities for approximately 4,100 single undergraduate women, 4,900 single undergraduate men, 254 single graduate men, 136 graduate women, 1236 family apartments, and apartment space for 720 single students. Chapter houses are maintained near the campus by 31 fraternities and 16 sororities. They house approximately 2,400 students. Other students live in private rooms and apartments in Ames or nearby communities.

Each newly admitted student to the University who requests housing information will receive a housing application form with his/her letter of admission. The student's name will be placed on the waiting list for assignment according to the date the completed application and housing deposit are received in the Department of Residence Administrative Office. Admission to the University is necessary before obtaining a housing application.

A deposit is required at the time an application form is completed for accommodations in the residence halls or when an application card is completed for a family apartment or single student apartment operated by the University.

Address correspondence concerning undergraduate and graduate single student housing to the Administrative Office, Department of Residence, 1215 Friley Hall, Iowa State University, Ames, Iowa 50012, or to the Director of University Student Apartments, 100 University Village, Ames, Iowa 50010, for family or single student apartments.

Graduate Residence Hall

Buchanan Hall provides housing in 174 single occupancy rooms and 108 double occupancy rooms for single graduate students and single adult undergraduate students. A suite-type room plan provides a semiprivate bath shared by the occupants of two single rooms or two double rooms. Public areas include a lounge, television room, recreation area, vending room, laundry room, and administration office.

Rooms are furnished with single beds, innerspring mattresses, chests of drawers, individual study desks, chairs, and room telephone. Bed linens are furnished and maid service is provided weekly. Students provide towels and study lamps.

The room rate as of June 1980 was $714 per academic year in a double room, or $939 per academic year in a single room. A meal ticket may be purchased (for $861 per academic year as of June 1980) to eat in a residence hall dining room.

Single Student Apartments

There are 105 two-bedroom apartments in Schilletter Village designated for use by single students. The rate for these apartments as of July 1980 was $279 per month per apartment. Each apartment normally houses 4 students.

The apartments are furnished with the same furniture used in the undergraduate residence hall rooms plus range and refrigerator. Water service and trash removal are included in the rent. Students pay their own gas, electricity and telephone.

There are also 150 one bedroom apartments in Pammel Court designated for use by single students. Pammel Court units are furnished with range, refrigerator, drapes, bunk beds and mattresses. Water service and trash removal are included in the $90.00 (July 1980) a month rental rate. Students pay their own gas, electricity and telephone. Each apartment houses two single students.

Family Apartments

The University provides 155 apartments in Schilletter Village, 500 apartments in University Village, 196 apartments in Hawthorn Court, and 370 apartments in Pammel Court for student families. Rates for these apartments as of July 1, 1980 were $174 per month for Schilletter Village, $159.50 per month for University Village, $148 per month for Hawthorn Court, and $65-$70 per month for Pammel Court. Apartments are unfurnished except for ranges and refrigerators, which are provided in all but Pammel Court. Family apartments in Pammel Court have ranges but not refrigerators. Water service and garbage removal are included in the rental. Residents pay for their own gas, electricity, and telephone.

Approximately 40% of Iowa State's student families live in university apartments. The remainder find accommodations in private homes, apartments, and trailer courts in and near Ames or commute from surrounding communities.

A list of off-campus apartments for student families may be seen at the University Student Apartment Office; however, the majority of the available rentals may be obtained from local newspapers and real estate offices.

Applications for University Student Apartments will be accepted not more than one year in advance of attending the University. Assignments are made by date of application.

Address correspondence concerning student apartments to the Director of University Student Apartments, 100 University Village, Ames, Iowa 50010.

Off-Campus Housing for Single Students

Availability and cost are factors to be considered when living off-campus, as the number of good living quarters is limited. Sleeping rooms in older houses and apartments make up the bulk of off-campus housing.

The Single Off-Campus Housing Office, 1212 Friley Hall, keeps a partial listing of off-campus sleeping rooms and apartments. Other housing may be obtained through real estate agents, local newspapers, or by contacting individual owners.

It is best that the student come to Ames well in advance of the time he or she plans to begin academic work, as many rooms and apartments are rented 3 to 6 months in advance. Because

of the variety, it is best to contact the owner directly to make arrangements for housing that will fit requirements of the individual.

The single occupancy room rental rates average $25 per week; the double occupancy room rental room rates average $20 per person per week. The student usually furnishes bed linens, towels, and study lamp. Average rental rate per student sharing an apartment or house would be in the $75 to $85 range per month. Board for students living in off-campus rooms may be obtained in residence hall dining rooms, private restaurants, or the Memorial Union.

Research and Service Agencies

Research is an important activity at Iowa State. Most faculty members engage in research pursuits as well as teaching. Graduate students, and in some cases undergraduates, receive stimulation which comes from being a part of the never-ending search for new knowledge. Therefore, new developments and new ideas pervade the campus.

A year's operating budget for all research at the University is approximately $53 million, much of it from contracts or grants involving the federal government and industry.

As part of its total program the University also operates extension services, special laboratories, and institutes.

An abbreviated description of the various research and service agencies and their administrative personnel is presented here. Additional information concerning any of these organizations may be obtained from the offices located on the campus.

Agriculture and Home Economics Experiment Station

Lee R. Kolmer, Ph.D., Director
John P. Mahlstede, Ph.D., Associate Director
Ruth E. Deacon, Ph.D., Assistant Director
Thamon E. Hazen, Ph.D., Assistant Director
Ronald C. Powers, Ph.D., Assistant Director

Agricultural research at Iowa State traces its history to the beginning of the University, when the orginal farm provided an opportunity for research with livestock, crops, and horticultural material. The Hatch Act, passed by Congress in 1887, provided federal support for agricultural research investigations. The formal beginning of the Agriculture and Home Economics Experiment Station dates from that time. Additional federal, state, and private support enabled the Station to reach its present program in both basic and applied research.

In addition to work at the main station at Ames, experimental work is conducted at a number of outlying research centers and in the fields of many farmer cooperators throughout the state. These experimental areas have been selected to represent specific soil types and climate of the state where special problems can be studied on a local basis.

Currently, research is being conducted in: agricultural bacteriology, agricultural economics, agricultural education, agricultural engineering, agricultural journalism, agricultural statistics, agronomy, animal science, animal ecology, biochemistry, entomology, fisheries and wildlife biology, food technology, forestry, genetics, home economics, horticulture, plant pathology, seed and weed science, and sociology.

Ames Laboratory of the United States Department of Energy

Robert S. Hansen, Ph.D., Director
Velmer A. Fassel, Ph.D., Deputy Director
Eugene Catus, B.S., Associate Director
William J. Kernan, Ph.D., Associate Director
Kenneth L. Kliewer, Ph.D., Associate Director
Adolf F. Voigt, Ph.D., Assistant Director

Because of the outstanding record of achievment of the Iowa State project in atomic energy during the war years, the Atomic Energy Commission decided to continue this program of research in the nuclear and other energy-related fields at Iowa State University in the postwar period. Accordingly, it established on the campus one of its major research centers, known as the Ames Laboratory of the Atomic Energy Commission. This laboratory specializes in the basic research necessary to the development and utilization of energy resources of the country. On October 11, 1974 a federal legislative act abolished the Atomic Energy Commission and created the Energy Research and Development Administration which in turn was abolished with the establishment of the cabinet-level U.S. Department of Energy on October 1, 1977.

The University has leased areas on the campus to DOE for the location of Spedding Hall, the Metallurgy, and Metals Development buildings, and the former research reactor building. The Laboratory also provides research opportunities for more than one hundred and fifty graduate students and part-time work for a number of advanced undergraduate students.

The Laboratory's major research effort is in the basic sciences, and aims at providing the foundation for future energy technologies. Particular emphasis is directed at preparing new materials, whose chemical properties are characterized, evaluated and interpreted. Applied work builds on the Laboratory's strength in the basic sciences and includes programs in superconductors, environmental science, solar cells, and materials resistant to the severe environments found in energy conversion processes.

Center for Agricultural and Rural Development

Earl O. Heady, Ph.D., Director

The Center is a research organization concerned especially with the economic, social, political, and administrative problems related to the rapidly changing structure of agriculture, rural communities and the environment. Its work emphasizes that portion of the population outside metropolitan areas and the interrelationship of rural areas with urban problems. It develops and applies large-scale models relating to the economic structure of the agricultural sector.

The Center research program focuses on equity problems which accompany rapid national economic growth and the speeding technological transformation of agriculture. It conducts research aimed at measuring and explaining disparities in income, employment, welfare, and environmental conditions for residents of nonmetropolitan America as compared to those of urban centers. Analysis is also devoted to private and public means by which these disparities can be overcome and how the resources of rural areas can be used most effectively for national benefit and protection of environmental quality.

The broad complex of problems relating to income and welfate of people in agriculture and rural communities and the best use of resources in rural areas involves research at local, state, and national levels. Also, in integrating U.S. policies with international development and food aid possibilities, the Center maintains international projects in rural community and agricultural development. It is concerned with general policy of food production and agricultural income at both domestic and world levels.

Computation Center

Clair G. Maple, D.Sc., Director
Dale D. Grosvenor, Ph.D., Associate Director
Robert J. Lambert, Ph.D., Associate Director
George O.Strawn, Ph.D., Associate Director
Michael D. Bowman, M.S., Assistant to the Director
George F. Covert, M.S., Assistant Director, Systems
John B. Linderblood, Assistant Director, Operations
Jerome Niebaum, Ph.D., Assistant Director, Interactive Computing

The first digital computer to incorporate the concept of a memory was developed at Iowa State in the late 1930s by J. V. Attanasoff and his graduate student Clifford E. Berry, and was considered to be operational in 1940. This was just one, albeit an important one, of several events that have taken place on our campus in the last sixty years which led to the organization of the Computation Center in 1962 as a University-wide computing service and a centralized facility for research and education in the computing sciences.

University students, faculty and staff members having computational problems may use the computing service as well as the consulting services. The Center maintains a variety of computing facilities ranging from personal computers through large-scale digital and analog computers. Peripheral equipment is available to transfer data from punched paper tape, standard and mini-flexible diskettes and digital cassettes to other secondary storage devices compatible with the central computers. Remote job entry stations are located in several buildings around the campus and interactive terminals are available in clusters and individually at widely dispersed locations including the dormitories. An emphasis on interactive graphics has recently been added. The ability to control experiments in the laboratory, gather data and forward it to the central facilities for processing and have the results returned to the laboratory is available over the high speed datanet.

The Center offers non credit short courses in computer programming and related topics and provides liaison for academic departments offering formal courses using the computer. Research encompasses numerical mathematics, programming research, digital computer systems, and computer assisted instruction. Standardized programs and systems have been developed and acquired to support a wide range of applied research areas. These widely used packages include many of the common statistical packages, linear programming, selective dissemination of

information, solution of linear algebraic systems of equations, eigenvalue problems, simulation, and graphics support.

Energy and Mineral Resources Reseach Institute

Robert S. Hansen, Ph.D., Director
Velmer A. Fassel, Ph.D., Deputy Director
Eugene Catus, B.S., Associate Director
William J. Kernan, Ph.D., Associate Director
Kenneth L.Kliewer, Ph.D., Associate Director
Adolf F. Voigt, Ph.D., Assistant Director

During World War II, a small group of scientists and coworkers at Iowa State played a very important role in the atomic energy program. Through their efforts, a process was developed and demonstrated for making high purity uranium metal. Before the process was turned over to industry, more than 2 million pounds of uranium metal were produced on campus in a temporary building. Shortly after World War II, Major General Leslie R. Groves presented the Ames project employees with the Army-Navy "E" award for excellence in industrial production of a vital war material.

In order that the program of the University in this field might be carried forward in peacetime, the Iowa State University Institute for Atomic Research was authorized by the Iowa State Board of Regents on Nov. 1, 1945. The name of the Institute was changed to the Energy and Mineral Resources Research Institute in 1974.

The Institute coordinates and administers fundamental energy research programs. Specifically, its purposes are:

- To administer Iowa State University's contract with the U.S. Department of Energy for the operation of the Ames Laboratory.
- To build and maintain a strong group of scientists working in the fundamental phases of physics and chemistry as they apply to energy conversion processes; and to develop the applied science aspects of physics, chemistry, metallurgy, and engineering.
- To make available on campus a group of experts in current energy technologies who may be consulted by faculty who wish to apply these new tools to their own problems.
- To encourage voluntary cooperation and coordination of this type of research on the campus. Particular emphasis is placed on sharing information when it is needed from several different scientific fields.
- To implement research enabling graduate students to obtain the specialized knowledge they will need to do independent research in their fields. Formal course work is offered and degrees are awarded through several departments and colleges.

Engineering Research Institute

D. R. Boylan, Dean and Director

The Engineering Research Institute (ERI) was organized in 1904 as the research arm of the College of Engineering. ERI coordinates research involving all engineering academic departments.

Senior research personnel of ERI are also active in teaching. The major portion of the research activity is related to graduate instruction and training. Research projects are generally initiated and supervised by the staff. Research is funded by state appropriations and by industrial and government grants and contracts.

Major research programs include studies in: process chemistry, ceramic materials, electrical power systems, enzymic processes, computers, solid-state devices, gas dynamics, fluid mechanics, highway materials, turbomachinery, sanitary engineering, soils, structures, water resources, fluid power, coal processing, heat flow, alternate energy systems, microwave propagation, agricultural products utilization, tornado dynamics, wind effects, holography, biomedical engineering, transportation engineering, structural dynamics, and computaional aerodynamics.

Major laboratories are maintained for electron microscopy, low-turbulence aerodynamics, heat transfer, bituminous materials, sanitary engineering, soils, structures, computers, radio astronomy, high-voltage photoelasticity, turbomachinery, and nuclear research.

Facilities include aerodynamic shock tubes, low- and high-speed wind tunnels, chemical process pilot plants, x-ray and infrared spectrometers, microprobe analyzer, transmission and scanning electron microscopes, analog and digital computers, and nuclear reactor.

Technical service groups include machine shops, electronic shops, analytic laboratory, equipment inventory, editorial and technical illustrating service.

Home Economics Research Institute

Ruth Deacon, Ph.D., Director
Mary E. Heltsley, Ph.D., Associate Director

The Home Economics Research Institute, established in 1966, operates as a part of the College of Home Economics. Objectives of the research are coordinated with those of the resident instruction and extension programs in home economics with emphasis on the family, education for effective family living, and provision of goods and services needed by individuals and families.

Research in home economics is administered by the Institute and the Agriculture and Home Economics Experiment Station.

Research is conducted in the fields of child development, family environment, food and nutrition, home economics education, institution management, and textiles and clothing.

Industrial Relations Center

Paul M.Muchinsky, Ph.D., Director

Concern over the profound impact of economic and social change in a dynamic economy led to the establishment of an Industrial Relations Center at Iowa State University by the Board of Regents in June 1966.

The Center's primary focus is on interdisciplinary research to increase our knowledge about the behavior of both individuals and organizations in the employment relationship. Faculty members associated with the Center come principally from the disciplines of economics, educational administration, industrial engineering, political science, psychology, and sociology. Through an interdisciplinary Graduate College faculty committee the Center administers an M.S. degree program in industrial relations.

The research is catholic in nature, reflecting the broad spectrum of the field of industrial relations as a discipline and also the diverse interests of some 20 Iowa State faculty members currently active in the Center's research and teaching programs. Research currently in progress includes employee selection and placement studies, quantitative behavioral research in manpower economics, and empirical research on public policy issues affecting industrial relations.

As an interdisciplinary entity embracing faculty from several different disciplines and three colleges, the Center is funded primarily by the University. The Center also obtains funding from specific grants and contracts from private and governmental sources.

North Central Regional Center for Rural Development

Ronald C. Powers, Ph.D., Director

The Center is a research and extension organization supported by the land grant universities of the North Central Region and the U.S. Department of Agriculture. Its purpose is to develop and implement research and extension programs in rural development for states in the region. This purpose is attained through research by faculty at Iowa State University and cooperative projects with personnel of other land grant universities in the region. The Center also assists in extension programs through the development of materials and the training of rural development personnel in the region.

A major activity of Center personnel, in cooperation with specialists and administrators of other universities, is to develop systematic and coordinated research and extension programs related to major problems of rural development in the North Central Region. The Center is governed by a Board of Directors representing the land grant universities in the region, USDA and the Farm Foundation. Advice to the Center is provided by representatives of several regional research and extension committees.

The Center sponsors conferences and workshops cooperatively with the universities in the region and with other regional centers. These conferences are developed as a means of bringing together current knowledge about such rural development problems as industrialization, community services, housing, quality of life, and processes of rural development.

Nutritional Sciences Council

Jerry W. Young, Ph.D.

The Nutritional Sciences Council consists of faculty members and qualified collaborators who are engaged in research, extension, or teaching in the nutritional sciences and closely related disciplines. Membership is by election. The Council develops symposia on topics of international interest, sponsors an interdepartmental seminar, "Modern Views of Nutrition," and arranges short courses designed to fill specific needs in the total nutrition program. It promotes evaluation and coordination of teaching and research programs in the nutritional sciences. The governing body is a seven-member advisory committee elected from the membership of the Council.

Physiology Council

Neal R. Cholvin, D.V.M., Ph.D.

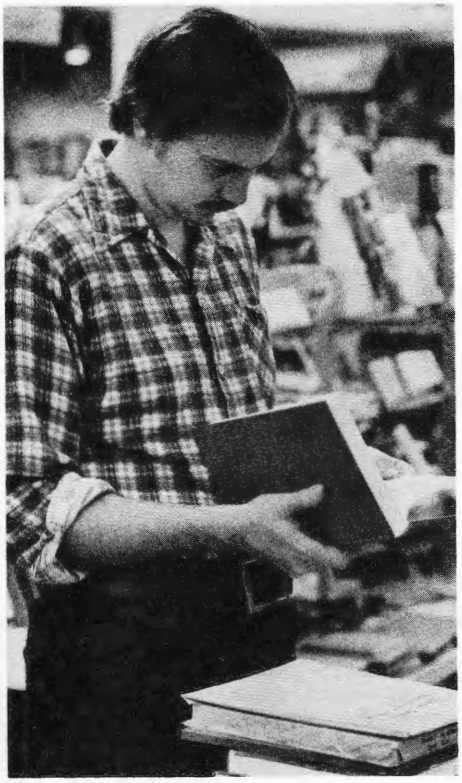
J. D. Blaustein, Zoology, August 31, 1983; N. R. Cholvin, Biomedical Engineering, August 31, 1981; C. D. Drewes, Zoology, August 31, 1981; R. L. Engen, Veterinary Physiology and Pharmacology, August 31, 1982; S. P. Ford,

Animal Science, August 31, 1983; J. N. Hathcock, Food and Nutrition, August 31, 1982; A. H. Trenkle, Animal Science, August 32, 1982.

The Physiology Council consists of interested faculty members who are engaged in research and instruction in physiology and closely related areas. The Council encourages cooperation between departments and promotes development and coordination of unique and interdisciplinary programs, seminars, and symposia of interest to physiologists.

Various aspects of graduate study and research in physiology are supervised in the following departments: Animal Ecology, Animal Science, Biomedical Engineering, Botany, Entomology, Food and Nutrition, Veterinary Physiology and Pharmacology, and Zoology. Co-majors in these departments are possible. In addition, training and research in certain aspects of applied physiology are supervised in the following departments: Agronomy, Biochemistry and Biophysics, Forestry, Genetics, Horticulture, Microbiology, Physical Education, Veterinary Microbiology and Preventive Medicine, and Veterinary Pathology.

By special arrangement, certain facilities and equipment may be made available by the Veterinary Medical Research Institute, National Animal Disease Center, and the Iowa State Energy and Mineral Resources Research Institute.



Research Institute for Studies in Education

Richard D. Warren, Ph.D., Director

The Research Institute for Studies in Education, established in 1974, stimulates, conducts and/or coordinates research activities in the College of Education.

The Institute's programs focus on problems in the development of educational personnel for academically related careers; problems in teaching and learning, human behavior motivation and modification, educational pedagogy and assessment.

Research activities are directly concerned with, but not limited to, teacher education in the major areas of elementary, secondary, graduate, and continuing education. Research is conducted in areas of specialization such as: adult education, agricultural education, educational administration, elementary education, secondary education, higher education, home economics education, curriculum and instruction, guidance and counseling, industrial education, philosophy of education, vocational-technical education, and areas cognate to the College of Education's commitment to the preparation of educational personnel.

The research programs are implemented through research activities of Institute staff, faculty, and graduate students. In engaging in research the Institute cooperates with other colleges and research institutes within the University and other universities in the state, with schools, school districts, area schools, the Iowa State Department of Public Instruction, other state departments of education, regional educational research centers, national research centers, and various agencies of the federal government.

Sciences and Humanities Research Institute

Wallace A. Russell, Ph.D., Director
Thomas W. Turnage, Ph.D., Associate Director

Research programs in the College of Sciences and Humanities are sponsored, coordinated and administered through the Sciences and Humanities Research Institute. Its primary objective is to encourage basic research and creative scholarship in the five major areas included in the college—the humanities, the social sciences, the biological sciences, the physical sciences, and the mathematical disciplines. These activities are carried out, with support from the Institute, by faculty members of the college and by graduate students working in these areas. In addition, the Institute works closely with other research agencies, both on campus and off, and administers externally funded sponsored research within the college.

In extending the frontiers of knowledge, these activities contribute directly to the University's educational mission. In addition, they provide ideas and results which may aid in the solution of both present and future problems of the state and the nation.

Soil Science Institute

Wayne H. Scholtes, Ph.D., Director

The Soil Science Institute is a multidisciplinary institute with the objective of conducting instruction of most current information in the subject matter areas supportive to the field of soil genesis and classification. Since its inception at ISU in 1966, it has been offered every other year for selected soil scientists from the U.S. Department of Agriculture.

The institute includes 10 cooperative staff members specializing in the instruction of climatology, crop physiology, statistics, geomorphology, soil chemistry, soil classification, soil engineering, soil fertility, soil genesis, and soil physics.

Statistical Laboratory

Herbert A. David, Ph.D., Director

The Statistical Laboratory is a research and service institute which conducts research in statistical theory and methodology. It promotes and fosters the use of sound statistical methods in university research through on-campus consulting. Established in 1933, it was the first statistical center of its kind in the United States.

The Laboratory cooperates closely with research workers in all colleges of the University. Staff and facilities are maintained for statistical consulting aid, statistical numerical analysis and data processing, sample survey operations, and statistical design and analysis of surveys and experiments. Similar consulting aid, research cooperation, and services are extended to off-campus groups, other colleges and universities, and civic groups when such activities are of mutual benefit or otherwise in the public interest.

Veterinary Medical Diagnostic Laboratory

Vaughn A. Seaton, D.V.M., M.S., Head

The Veterinary Medical Diagnostic Laboratory was established in 1947 to provide a facility to which the Iowa animal industry and veterinary medical profession can bring their problems for counsel and assistance. Through the Laboratory, the technical and professional assistance of the College of Veterinary Medicine can be made available. The Laboratory functions in all discipline areas of veterinary medicine necessary to provide diagnostic assistance. It is organized into functioning units of pathology, mucrobiology, and chemistry-toxicology with all their pertinent sub-disciplines.

The Laboratory is an integral part of the College of Veterinary Medicine. It is a valuable link between the practicing veterinarian and the teaching and research staff of the College of Veterinary Medicine and through this link many areas of research have been expanded. The Laboratory annually receives thousands of specimens from all parts of Iowa for examination. It cooperates closely with the state and federal disease control and public health agencies on the local, state, and national levels.

The Diagnostic Laboratory serves as a teaching laboratory for both undergraduate and graduate students in the College of Veterinary Medicine. In this laboratory the students assist with field disease problems and receive firsthand information regarding the total disease picture, including history, symptoms, treatments, postmortem examinations, gross and microscopic examinations, and a host of diagnostic procedures and techniques in all veterinary medical disciplines in the characterization and identification of etiological agents. In addition, the laboratory is engaged in research projects concerned with animal disease problems as well as new techniques of diagnosis of animal diseases.

The modern physical plant of the laboratory is equipped with diagnostic and analytical facilities and instrumentation used in microbiological, chemical, toxicological, and pathological examination.

Veterinary Medical Research Institute

Phillip T. Pearson, D.V.M., Ph.D., Director
Melvin S. Hofstad, D.V.M., Ph.D., Professor in Charge

The Veterinary Medical Research Institute has a multidisciplinary faculty with a responsibility to conduct research and offer research training in animal diseases. Research and research

training are conducted in the areas of viral, bacterial and parasitic diseases, immunology and basic biology.

The Veterinary Medical Research Institute occupies land adjacent to the new College of Veterinary Medicine at the southeast edge of the campus. It has a complement of research laboratories and animal isolation units.

The Institute includes 10 professional faculty members with specialized training in the fields of parasitology, epidemiology, microbiology, pathology, physiology, and biochemistry, and their supporting staff.

No graduate courses are offered by the Institute; however, faculty members hold academic appointments in the departments of the College of Veterinary Medicine and memberships in the graduate faculty. This arrangement allows the faculty to advise graduate students and to offer research training opportunities through predoctoral, postdoctoral, and visiting scientist training programs.

The faculty of the Institute also participates in the instructional programs of the College of Veterinary Medicine by assisting the academic departments in their course offerings.

Water Resources Research Institute

Merwin D. Dougal, Ph.D., Director
Daniel J. Zaffarano, Ph.D., Administrative Coordinator

The Iowa State Water Resources Research Institute was established in 1964 as the designated state organization to accept funds and administer the state-federal water resources research program of the U.S. Department of Interior. Coordination is maintained with the Office of Water Research and Technology, U.S. Department of Interior, and with regional organizations of the water institutes in the Missouri River basin and the Upper Mississippi River basin, in carrying out the responsibilities of this interdisciplinary program.

The purpose of the program is to assist in solving water problems in Iowa, the Midwest, and the nation. Identifying research needs, conducting research, training students, and disseminating information and the results of research through technology transfer and extension are major objectives. The Institute operates under the guidance of the ISWRRI Council, composed of seven faculty members at Iowa State University and four at the University of Iowa. These members represent a broad cross-section of the water-related disciplines in the sciences, humanities, and engineering phases of education, research, and extension. A research advisory board composed of technical representatives of state and federal water agencies assists the Institute in carrying out its program. Faculty members participating in the program represent many disciplines in the scientific-engineering-social-economic-legal-institutional framework within which the water resources of the nation are developed for beneficial use.

The Institute sponsors research projects on a broad variety of subjects. Proposals usually originate with the faculty, using OWRT and ISWRRI guidelines and priorities. Support of graduate students at the master's and the Ph.D. level is emphasized so that students develop the specialized knowledge and skills necessary for continuing in these water-related fields. Several specific problem areas of water resources have been outlined, and a research team approach has been implemented for identifying additional research needs and for conducting the required research. Close coordination is also maintained with research groups at other colleges and universities in Iowa.

The Institute sponsors conferences, symposia, and workshops and publishes the results of research and all symposia. It is closely associated with the multidisciplinary water resources graduate program at Iowa State and the comparable program at the University of Iowa.

World Food Institute

Charlotte Roderuck, Ph.D., Director

The World Food Institute of Iowa State University was officially established in 1972 by the Iowa Board of Regents to focus Iowa State University's competencies and leadership upon the provision of adequate and nutritious food supplied for the world's peoples through research and education. The World Food Institute's five major goals are: (1) To analyze food and nutrition problems; (2) To generate solutions to food and nutrition problems and to suggest means for implementation of solutions; (3) To build competencies in people for the generation and implementation of solutions of food and nutrition problems: (4) To collect, analyze, and disseminate information bearing on food and nutrition problems; and (5) To study interrelationships between the United States, with particular emphasis on Iowa, and other countries of the world.

General policy decisions concerning the Institute are made by the Faculty Policy Committee. Members of the Faculty Policy Committee are appointed by the Vice President for Academic Affairs and are selected from among recommendations made by the deans of Iowa State University's colleges through the World Food Institute director. The Faculty Policy Committee is subdivided into three study areas — research, education, and extension. Problem areas are defined in these areas and the Faculty Policy Committee may recommend the establishment of a task force by the World Food Institute director.

Faculty members who have a research project, education activity, or extension program relating to world food problems are encouraged to contact the director of the Institute. The project will be evaluated, and if accepted will be classified as: *Contributing Project* — A project funded entirely by the World Food Institute or by agencies through the World Food Institute; *Affiliated Project* — A project jointly funded by the World Food Institute and a college, department, experiment station, or other institute on campus; *Auxiliary Project* — A project funded entirely by a college, department, experiment station, or other institute but which, because of emphasis on food problems, may be listed as a World Food Institute project.

University Extension

Charles E. Donhowe, dean

Through the combined University Extension program, the total resources of Iowa State can be brought to bear on urban and rural problems. University Extension includes all extension programs emanating from Iowa State. Most of the efforts are organized through the extension units.

Cooperative Extension Service in Agriculture and Home Economics — Charles E. Donhowe, director. Among the programs offered are agricultural production, conservation of national resources, efficient marketing and distribution of farm-raised products, family living, 4-H club work, youth development, community improvement and resource development.

Engineering Extension — R. E. Patterson, Jr., director. Both non-credit courses and video-taped graduate-credit courses taught by faculty members from the College of Engineering are offered throughout the state.

Center for Industrial Research and Service (CIRAS) — David H. Swanson, director. An advisory service to Iowa industry and business. The center facilitates the dissemination of counsel and assistance in solving the operational problems of industry and business in the private sector.

Office of Continuing Education — George H. Ebert, leader. Extension courses, off-campus university credit courses, and informal continuing education programs are offered as part of the broad, educational and service base of the University.

Courses and Programs

Information About Courses

Course Numbers

The courses in each department are numbered from 1 to 699, according to the following groups:

1- 99 — Courses not carrying credit toward a degree.
100-299 — Courses primarily for freshman and sophomore students.
300-499 — Courses primarily for junior and senior students.
500-599 — Courses primarily for graduate students, but open to qualified undergraduates.
600-699 — Courses for graduate students only.

Credits and Contact Hours

The academic value of each course is stated in semester credits. Each credit is normally earned by attending one (50-minute) hour of lecture or recitation per week for the entire semester, or by attending a laboratory or studio period of two or three hours per week. In addition, undergraduate students typically will be expected to spend two hours in preparation outside of class for each lecture or recitation hour; additional outside work may be required for laboratory or studio classes.

Each course states the number of semester credits assigned to the course, preceded in parentheses by the number of hours in class (contact hours) expected of the student. The first of the two contact-hour numbers indicates the number of lecture or recitation class hours per week for the semester. The second is the number of laboratory or studio hours required per week.

The term "Cr. arr." means that the amount of credit is arranged in advance between the student and the instructor. The credit to be earned depends on the amount of work expected of the student, in accordance with the policy that some combination of teacher-student contact and outside work by the student involving at least three hours per week for the entire semester is required for each credit.

The term "Cr. R." means that the course is required in a certain curriculum, but no credit is given.

Semester of Offering

Within each course description may be found one or more of the following letters: F. S. SS., indicating which term — fall, spring, summer session — of the academic year the course is offered. "Alt." is the abbreviation for alternate. The abbreviation "Yr." is used to designate a sequence of two courses taught fall and spring, respectively. If there is sufficient demand, courses may be offered more frequently than announced.

Course Prerequisite

A prerequisite indicates the specific academic background, or general academic maturity, considered necessary for the student to be ready to undertake the course. Prerequisites are usually stated in terms of specific courses, but equivalent preparation is usually acceptable. An instructor may, however, direct a student whose background does not meet the stated prerequisite, or its equivalent, to drop the course. Conversely, an instructor may waive the prerequisite for a course for which he or she is responsible. Thus, permission of the instructor is understood to be an alternate to the stated prerequisites in all courses.

Designators

For a list of abbreviations designating departments and programs, see page 16.

Graduate Programs

Graduate Major

A major in the Graduate College is the area of academic professional concentration, approved by the Board of Regents, in which the student chooses to qualify for the award of a graduate degree.

Graduate Area of Specialization

Areas of specialization are indicated in the graduate statements of some departments. This is a subdivision of a major in which a strong graduate level program is available. When approved by the Graduate College, such areas of specialization are shown parenthetically after the major on official records and transcripts.

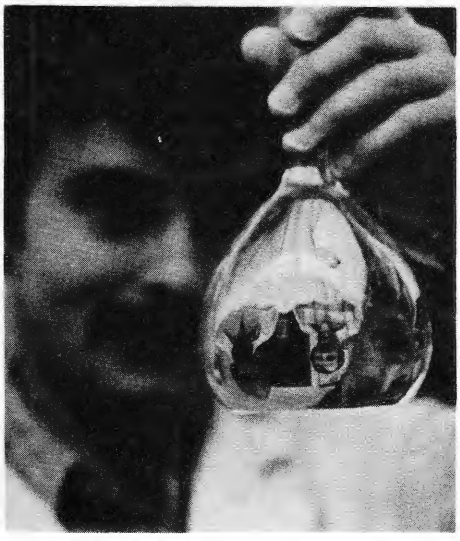
Interdepartmental Programs

Interdepartmental programs are available at both graduate and undergraduate levels. An interdepartmental program is an administrative structure usually not functioning as a department, ordinarily headed by an advisory committee, and offering a degree with major(s) in that subject area. Interdepartmental programs have been officially approved and may offer courses.

Designators

Acct	Accounting
A E	Agricultural Engineering
A Ecl	Animal Ecology
Ad Ed	Adult and Extension Education
Aer E	Aerospace Engineering
AFAS	Air Force Aerospace Studies
Ag Ed	Agricultural Education
Ag M	Agricultural Mechanization
Ag St	Agricultural Studies
Agron	Agronomy
Am In	American Indian Studies
An S	Animal Science
Anthr	Anthropology
Arch	Architecture
Art	Art and Design
Astro	Astronomy and Astrophysics
Ath	Athletics
B B	Biochemistry and Biophysics
B M E	Biomedical Engineering
Biol	Biology
Bot	Botany
BusAd	Business Administration
C D	Child Development
C E	Civil Engineering
C Grk	Classical Greek
Ch E	Chemical Engineering
Chem	Chemistry
Cl St	Classical Studies
Co Ed	Counselor Education
Com S	Computer Science
Con E	Construction Engineering
Cpr E	Computer Engineering
C R P	Community and Regional Planning
Curr	Curriculum and Instructional Media
Dance	Dance
Dsn S	Design Studies
E E	Electrical Engineering
E M	Engineering Mechanics
E Op	Engineering Operations
E Sci	Engineering Science
Ea Sc	Earth Science
Econ	Economics
EdAdm	Educational Administration
El Ed	Elementary Education
Engl	English
Ent	Entomology
Env S	Environmental Studies
F E	Family Environment
Fin	Finance
F Lng	Foreign Languages and Literatures
F N	Food and Nutrition
F Tch	Food Technology
For	Forestry
Fr E	Freshman Engineering
Frnch	French
GP S	Geodesy, Photogrammetry, and Surveying
Gen	Genetics
Geog	Geography
Geol	Geology
Ger	German
Gr St	General Graduate Studies
H Ed	Home Economics Education
HE St	Home Economics Studies
H P C	Historical, Philosophical, and Comparative Studies in Education
H S	Health Studies
Hg Ed	Higher Education
Hist	History
Hort	Horticulture
Hous	Housing
I A S	Industrial Administrative Sciences
I E	Industrial Engineering
I Ed	Industrial Education
I Mgt	Institution Management
I R	Industrial Relations
Imbio	Immunobiology

Ital	Italian
IVTE	Industrial Vocational Technical Education
Jl MC	Journalism and Mass Communication
L A	Landscape Architecture
L S	Leisure Studies
Latin	Latin
Lib	Library
M E	Mechanical Engineering
M S	Military Science
M S E	Materials Science and Engineering
Math	Mathematics
MCDB	Molecular, Cellular and Developmental Biology
Mgmt	Management
Micro	Microbiology
Mkt	Marketing
Mteor	Meteorology
Music	Music
N S	Naval Science
Nuc E	Nuclear Engineering
P E	Physical Education
P M	Pest Management
Phil	Philosophy
Phys	Physics
Pol S	Political Science
Port	Portuguese
PP SW	Plant Pathology, Seed and Weed Sciences
ProAg	Professional Agriculture
Pr St	Professional Studies in Education
Psych	Psychology
Relig	Religious Studies
ResEv	Research and Evaluation
Rus	Russian
SafEd	Safety and Driver Education
S-H	Sciences and Humanities
SecEd	Secondary Education
Soc	Sociology
Sp	Speech
Span	Spanish
Stat	Statistics
T C	Textiles and Clothing
TrLog	Transportation/Logistics
Tr Pl	Transportation Planning
T SC	Technology and Social Change
U St	University Studies
V An	Veterinary Anatomy
V C S	Veterinary Clinical Sciences
V Med	Veterinary Medicine
V MPM	Veterinary Microbiology and Preventive Medicine
V P P	Veterinary Physiology and Pharmacology
V Pth	Veterinary Pathology
W Res	Water Resources
W S	Women's Studies
Zool	**Zoology**



Aerospace Engineering

Lennox N. Wilson, Acting Head of Department

The Graduate Faculty

Members: Anderson, Hsu, Iversen, McDaniel, Peterson, Pierson, Tannehill, Vogel, Wilson

Associate Members: James, Seversike, Vogel

The department offers work for the degrees Master of Engineering, Master of Science, and Doctor of Philosophy with major in aerospace engineering, and minor work to students taking major work in other departments. For all graduate degrees, it is possible to establish a co-major program with another graduate degree granting department. Within the aerospace department, work is available in the following areas: computational aerodynamics, optimization, atmospheric and tornado sciences, control systems, atmospheric and space flight mechanics, structural analysis, gasdynamics, turbulence, combustion, and swirling flow.

The major work for the degrees Master of Science and Doctor of Philosophy requires an acceptable thesis in addition to the course work. For the degree Master of Engineering, a comprehensive paper or suitable project as evidence of independent accomplishment is required. Appropriate credit is allotted for this requirement.

Minor work for aerospace engineering majors is usually selected from mathematics, physics, electrical engineering, engineering mechanics, mechanical engineering, and meteorology.

The normal prerequisite to major graduate work in aerospace engineering is the completion of a curriculum substantially equivalent to that required of aerospace engineering students at this University. However, because of the diversity of interests within the graduate programs in aerospace engineering, a student whose prior undergraduate or graduate education has been in allied engineering and/or scientific fields may also qualify. In such cases, it may be necessary for the student to take additional work to provide the requisite background in a chosen area of interest. A prospective graduate student is urged to specify the degree program and the specific field(s) of interest on the application for admission.

Courses normally will be offered as stated in the course description. Where no specific time of offering is stated, the course may be offered during any semester provided there is sufficient demand.

The department also participates in the interdepartmental programs of Energy Systems Engineering, and Technology and Social Change. (See Index.)

Courses for Graduate Students, minor only

321. Flight Structures Analysis. (3-0) Cr. 3. S. *Prereq: E M 324, M S E 371.* Determination of flight loads. Materials selection for flight applications. Analysis of flight structures in unsymmetric bending, bending of two-material beams, torsion, shear flow due to bending and torsion in thin-walled structures, elastic instability.

341. Aerodynamic Theory I. (3-0) Cr. 3. F. *Prereq: Math 266.* Incompressible potential flow, Euler's equations, thin airfoil and finite wing theory.

342. Aerodynamic Theory II. (3-0) Cr. 3. S. *Prereq: 341, M E 330 or 331.* Energy equation, compressible flow, shock and expansion waves, linearized subsonic and supersonic flow, transonic flow, hypersonic flow.

351. Astrodynamics I. (3-0) Cr. 3. F. *Prereq: Math 265, E M 345.* Introduction to astrodynamics, two-body motion, coordinate systems, launch vehicle trajectories, and atmospheric entry trajectories. Orbital transfer methods, lunar and interplanetary trajectories.

355. Flight Vehicle Stability and Control. (3-0) Cr. 3. S. *Prereq: 242, Math 267, E M 345.* Aircraft rigid body equations of motion. Longitudinal and lateral-directional static and dynamic aircraft stability and control. Flight handling characteristics.

411. Aerospace Vehicle Propulsion I. (3-0) Cr. 3. F. *Prereq: 342.* Fanno and Rayleigh flows. Combustors and combustion. Three-dimensional flows in nozzles, diffusers, and ducts. Principles of internal combustion engines, turbojet, turbofan, turboprop, ramjet, and rocket propulsion systems.

412. Aerospace Vehicle Propulsion II. (3-0) Cr. 3. S. *Prereq: 411.* Performance, dynamics, and control of turbo-engines. Blade element theory applied to propellers, axial flow compressors, turbines, and fans. Engine core and jet noise. Solid and liquid rocket engine construction and operation. Nuclear and electrical propulsion.

419. Principles and Techniques of Remote Sensing. (C E 419) (3-0) Cr. 3. F. *Prereq: Phys 222.* Principles, techniques, and accuracies of remote sensing methods. Principles of photographic systems, radar, passive microwave, infrared, visible and ultraviolet imaging, with capabilities, limitations and utilization of each system.

421. Advanced Flight Structures. (3-0) Cr. 3. F. *Prereq: 321, Math. 266.* Analysis of indeterminate flight structures. Application of finite element analysis to flight structures. Introduction to dynamic analysis of wing and fuselage structures.

422. Aeroelastic and Thermal Analysis of Flight Structures. (3-0) Cr. 3. S. *Prereq: 421.* Analysis of static and dynamic deformation of elastic aerospace structures. Introduction to aeroelasticity, wing divergence, and flutter. Analysis of hot structures.

431. Flight Control Systems I. (3-0) Cr. 3. F. *Prereq: 355.* Linear systems analysis using frequency response and root locus methods. Aircraft automatic controls systems and stability augmentation.

432. Flight Control Systems II. (3-0) Cr. 3. S. *Prereq: 431.* Aircraft inertial cross-coupling stabilization. Launch vehicle pitch control system design. Control system design for flexible vehicles. Active satellite attitude control. State variable description of flight control systems. Pole placement controller design. Introduction to sampled-data systems.

441. Aerodynamic Theory III. (3-0) Cr. 3. S. *Prereq: 342.* Viscous flow theory. Boundary layer. Aerodynamic heating.

442. V/STOL Aerodynamics and Performance. (3-0) Cr. 3. S. *Prereq: 341, 355.* Introduction to the aerodynamics, performance, stability, control and critical maneuvering characteristics of aerospace vehicles such as V/STOL aircraft, helicopters, hovercraft, and other short-range transportation vehicles.

451. Astrodynamics II. (3-0) Cr. 3. S. *Prereq: 351.* Orbit determination and prediction methods. Many-body problem. General and special perturbation methods as applied to satellite and spacecraft trajectories. Introduction to universal variable methods.

455. Flight Systems Testing. (2-3) Cr. 3. S. *Prereq: 355.* Principles of flight testing. Techniques of data acquisition and data analysis. Planning a flight test program. Conducting a flight test program. Fee charged for use of university aircraft.

461. Design and Analysis I. (1-6) Cr. 3. F. *Prereq: Senior classification.* Application of the principles and methods of analysis and synthesis in the solution of aerospace engineering design problems with emphasis on aircraft design.

462. Design and Analysis II. (1-6) Cr. 3. S. *Prereq: 461.* Preliminary design of aerospace vehicles. Detail design of aerospace vehicle components. Fundamental principles used in engineering development of aircraft, missile, and space systems.

464. Spacecraft Systems Engineering (3-0) Cr. 3. S. *Prereq: 461, Phys 222, E E 441.* Space environment, spacecraft, launch vehicle integration, placement in orbit, attitude control systems, attitude sensing systems, space communications, space power, thermal control, structures and mechanisms, scientific instruments.

485. Introduction to Hydrospace Engineering. (3-0) Cr. 3. S. *Prereq: 341, 355, Phys 222.* Introduction to elementary hydrospace vehicle performance, stability and control.

Courses Primarily for Graduate Students, major or minor

521. Airframe Analysis. (3-0) Cr. 3. F. *Prereq: 421.* Analysis of static and dynamic stresses and deformations in continuous aircraft structures. Approximate and numerical analysis of static and dynamic stresses and deformations in airframe design by normal mode technique.

525. Advanced Aeroelasticity I. (3-0) Cr. 3. S. *Prereq: 521, 544.* Static aeroelastic analyses of flight vehicles and lifting surfaces. Lifting surface and panel flutter. Dynamic response and load studies of flight vehicles using normal modes.

531, 532. Automatic Controls for Flight Vehicles I, II. (3-0) Cr. 3 each. Alt. Yr. *Prereq: 531: 431; 532: 531.* Theory of automatic control of flight vehicles. Spacecraft attitude control. Control of flexible vehicles. Optimal controls. Adaptive controls.

533. Thermodynamics of Compressible Flow II. (M E 533) See Mechanical Engineering.

534. Experimental Gas Dynamics. (M E 534) See Mechanical Engineering.

541, 542. Advanced Aerodynamics I, II. (3-0) Cr. 3 each. Yr. *Prereq: 541: 341 or M E 424; 542: 541.* Classical flow theory, compressible fluid theories, shock wave studies, and applications to aerodynamic shapes.

543. Advanced Aerodynamics III. (3-0) Cr. 3. F. *Prereq: 542.* Applications of classical flow theory, compressible fluid theories, and shock theory to aerodynamic shapes.

544. Applied Wing Theory. (3-0) Cr. 3. F. *Prereq: Credit or classification in 541.* Methods of estimating the aerodynamic characteristics of swept and unswept, steady and oscillating wings in subsonic and supersonic flight.

546, 547. Computational Fluid Mechanics and Heat Transfer I, II. (M E 546, 547) (3-0) Cr. 3 each. Yr. *Prereq: 546: credit or classification in 541 or E M 571; 547: 546.* Introduction to finite difference methods used in modern engineering. Solution of example problems in fluid mechanics and heat transfer. 547: Application of computational methods to current problems in fluid mechanics and heat transfer.

551. Space Flight Mechanics. (3-0) Cr. 3. F. *Prereq: 351.* General equations of motion for rigid body flight vehicles. Coordinate systems and time keeping. Two-body motion orbit transfers. Patched conic and multi-conic interplanetary trajectories. Restricted three-body problem.

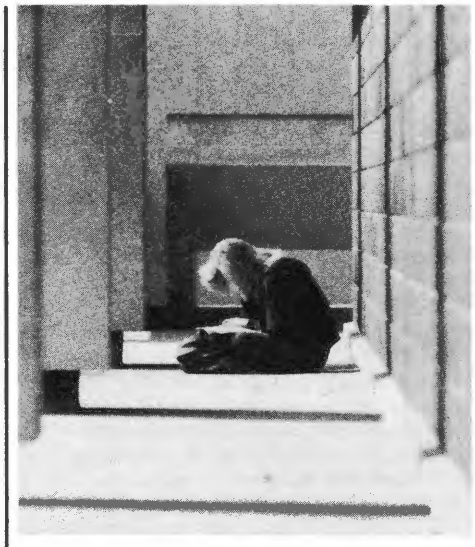
552. Entry Dynamics. (3-0) Cr. 3. S. *Prereq: 551.* Atmospheric entry and entry dynamics of missiles and spacecraft. Trajectory control. Descent and landing. Thermal protection considerations. Entry vehicle attitude control.

555. Atmospheric Flight Mechanics. (3-0) Cr. 3. S. *Prereq: 355.* Use of energy methods and optimization in the performance analysis of highly maneuverable aircraft and missiles. Stability and control analysis of flight vehicles. Introduction to parameter identification.

571. Environmental Aerodynamics. (3-0) Cr. 3. As arranged. *Prereq: 341.* Survey of atmospheric turbulence, turbulent diffusion, and velocity profile within the atmospheric boundary layer with emphasis on modeling by means of the environmental wind tunnel.

575. Tornado Fluid Mechanics. (3-0) Cr. 3. As arranged. *Prereq: 341.* Formation of atmospheric vortices, interaction of atmospheric vortices with the earth's surface, laboratory modeling of tornado vortices.

590. Special Topics. Cr. 1 to 5.
A. Aero and/or Gasdynamics
B. Propulsion
C. Stress Analysis
D. Flight Mechanics
E. Flight and Space Systems
F. Magnetofluiddynamics
G. Hydrospace
H. Viscous Aerodynamics
I. Design
J. Hypersonic Testing
K. Model Towing Basin Testing
L. Hypervelocity Testing
M. Computational Aerodynamics
N. Severe Storm Technology
O. Optimization



Courses for Graduate Students, major or minor

620. Seminar. (1-0) Cr. 1.

621. Aerospace Structures Analysis. (3-0) Cr. 3. S. *Prereq: 521.* The application of transfer matrix techniques to the analysis of various types of large aerospace structures under static, dynamic, and buckling loads.

625. Advanced Aeroelasticity II. (3-0) Cr. 3. As arranged. *Prereq: 525.* Aerodynamic and structural instabilities of fixed and rotating wing flight vehicles under discrete and random dynamic loads.

635, 636. Optimization in Aerospace Engineering I, II. (3-0) Cr. 3 each. As arranged. *Prereq: 635: 542; 551; 636: 635.* Applications of parameter optimization, dynamic programming and optimal control theory to problems in aerodynamics, aircraft structures, flight mechanics, design and performance. Singular optimal control problems. Pursuit/evasion differential games. Branched optimal trajectories. Optimal control of distributed parameter systems.

641, 642. Hypersonic Flow Theory I, II. (3-0) Cr. 3 each. As arranged. *Prereq: 641: 542; 642: 641.* High Mach number flows, Newtonian theory, small disturbance theory, constant density solutions, thin shock layers, blunt body problems, hypersonic boundary layers and viscous interactions.

645, 646. Magnetofluiddynamics I, II. (3-0) Cr. 3 each. As arranged. *Prereq: 645: 542; 646: 645.* Electromagnetic theory, equations of motion for viscous, heat and electrically conducting fluids of multiple species, wave motions, engineering problems in magnetohydrodynamics and magnetogasdynamics. Radiation gasdynamics.

647, 648. Dynamics of Real Gases I, II. (3-0) Cr. 3 each. As arranged. *Prereq: 647: 542; 648: 647.* Introduction of quantum theory and statistical mechanics to thermally and calorically imperfect gases, theories of harmonic and anharmonic oscillators, vibrational relaxing and chemically reacting flows behind a strong shock and through an expansion nozzle. Gasdynamic lasers.

650. Fluid Mechanics Seminar. (E M 650, M E 650) (1-0 to 3-0) Cr. 3 each time taken. F. *Prereq: Permission of instructor.* Special topics of current research interest to students and staff of departments concerned.

651, 652. Mechanics of Space Vehicles Maneuvers I, II. (3-0) Cr. 3 each. As arranged. *Prereq: 651: 551; 652: 651.* Vehicle orbital transfers, intercept and rendezvous problems, spacecraft and satellite attitude control using active and passive methods and entry vehicle control.

690. Advanced Topics. Cr. 1 to 5.
A. Aero and/or Gasdynamics
B. Propulsion
C. Stress Analysis
D. Flight Mechanics
E. Flight and Space Systems
F. Magnetofluiddynamics
G. Hydrospace
H. Viscous Aerodynamics
I. Design
J. Creative Component
K. Computational Aerodynamics

699. Research.

Agricultural Education

Harold R. Crawford, Head of Department

The Graduate Faculty

Members: Bundy (Emeritus), Crawford, Kahler, Williams

Associate Members: Carter, Hoerner, Lawrence

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in agricultural education and minor work to students taking major work in other departments. Candidates pursuing the Master of Science degree may do so by completing either a thesis or nonthesis program of study. Complete descriptions of these programs are available in the department.

The department cooperates with other departments in the College of Agriculture to offer work for a co-major Master of Science degree to prepare area school and community college agriculture teachers.

Prerequisite to major graduate work in agricultural education is preparation substantially equivalent to the completion of the undergraduate curriculum in agricultural education or agricultural extension education offered at Iowa State University and adequate proof that the student ranks above average in scholastic ability and promise of vocational competence.

Off-campus courses are offered for professional personnel in the field. Three-week courses and workshops are offered during the summer sessions.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Short Course in Agricultural Education. Cr. 1. *Prereq: Permission of instructor.* Specific problems, issues, and content areas in agricultural education. On and off campus on arranged basis.

511. Instructional and Organizational Problems of Beginning Teachers of Agricultural Education. (0-2) Cr. 1. F.S. *Prereq: 417.* Problems in instructional planning and methodology and in organizing the secondary, post-secondary, FFA, and agricultural experience programs.

512. Agricultural Education in the Career Development Process. (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 410, 411.* Humanistic components of the career development process. Relationship between self-concept development and current theories about work. Integrating agricultural education objectives and program activities into the career development process.

520. Instructional Methods for Teaching in Agricultural Education. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 411.* Innovations and advanced principles in teaching methods and materials. Group techniques including decision making, developing interest and understanding, and student evaluation. Individualized instructional techniques and evaluation of instruction.

521. Leadership Development in Agricultural Education. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 311.* Principles and practices of leadership development. Organization, implementation, and evaluation of individual and group leadership development in agriculture.

524. Program Development in Agricultural Extension Education. (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: Ad Ed 468.* Survey of agricultural needs and educational opportunities in local communities, counties and extension areas. Development of program objectives, implementation strategies, and evaluation procedures.

538. Young Farmer and Adult Education in Agriculture. (2-0) Cr. 2. Alt. SS., offered 1982. *Prereq: 410.* Problems and needs of young and adult farmers and workers in off-farm agriculture, survey techniques, uses of advisory councils, administrative relationship problems, program planning and evaluation.

539. Cooperative Occupational Experience Programs in Agriculture. (2-0) Cr. 2. Alt. SS., offered 1983. *Prereq: 311.* Organization, implementation, and administration of cooperative occupational experience programs in agriculture.

550. Occupational Guidance in Agriculture. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 411.* The guidance function of the agriculture teacher, agricultural extension worker, and other agricultural leaders; occupational information, planning, placement, and followup.

560. Role of Agricultural Education and Agricultural Extension in Technology Transfer. (2-0) Cr. 2. Alt S., offered 1983. *Prereq: Soc 415.* Processes by which formal and informal agricultural education programs and agricultural extension influence introduction and acceptance of agricultural technology.

590. Special Topics in Agricultural Education. Cr. 1-3. *Prereq: 12 credits in agricultural education.*
A. Curriculum
B. Methods
C. Philosophy
D. Evaluation
E. Administration
F. Leadership
G. Guidance

593. Workshop in Agricultural Education. Cr. 1-3. SS. *Prereq: 12 credits in agricultural education.*
A. Curriculum
B. Methods
C. Evaluation
D. Administration
E. Leadership
F. Guidance

599. Creative Component. For nonthesis M.S. degree programs.

Courses for Graduate Students, major or minor

604. Evaluation in Agricultural Education. (3-0) Cr. 3. Alt. F., offered 1981. Prereq: 410. Criteria and procedures for evaluation of programs in agricultural education. Selection and construction of evaluation devices. Use of results in program planning and implementation.

610. Curriculum Development in Agricultural Education. (3-0) Cr. 3. Alt. SS., offered 1982. *Prereq: 410.* Analysis of social, individual, and subject matter needs in agriculture and their impact on agricultural curricula. Application of new concepts and educational theory to curriculum planning in agricultural education.

615. Seminar in Agricultural Education. (1-0) Cr. 1. F.S.

617. Professional Development of Teacher Educators in Agricultural Education. (1-0) Cr. 1. F. *Prereq: Permission of instructor.* Analysis of the roles and activities of teacher educators in agricultural education with emphasis on identifying and describing future personal roles in higher education.

620. Research Procedures in Agricultural Education. (3-0) Cr. 3. S., 1982; SS., 1983. *Prereq: 9 credits in agricultural education and statistics.* Application of research methods to agricultural education research. Identification of research priorities, selection and development of research design, and critique of research in agricultural education.

625. Administration and Supervision of Agricultural Education Programs. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 520.* Management principles and practices of planning, organizing, directing, staffing and evaluating as applied to administration and supervision of programs in agricultural education.

630. Philosophy and Policy Making in Agricultural Education. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 410, 411.* Basic philosophic premises in development of agricultural education programs at federal, state, and local levels. Impact of legislation on state and local policy making. Role of state and local advisory groups in policy making.

699. Research.

Agricultural Engineering

Howard P. Johnson, Acting Head of Department

The Graduate Faculty

Members: Beer, Beresford (Emeritus), Buchele, Giese, Hazen, H. P. Johnson, Laflen, Marley, Morford (Emeritus), R. J. Smith

Associate Members: C. Anderson, Baker, Bern, Bundy, Erbach, Hoerner, Kline, Soderholm

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in agricultural engineering and minor work to students taking major work in other departments. Minor work is also offered in agricultural mechanization for students in the College of Agriculture, see *Agricultural Mechanization*. Within the major the student may specialize in soil and water resources, agricultural power and machinery, electric power and processing, and agricultural structures and environment.

Prerequisite to major graduate work is the completion of an undergraduate curriculum substantially equivalent to that required of agricultural engineering undergraduate students at this institution. However, because of the diversity of interests within the graduate programs in agricultural engineering, a student may qualify for graduate study even though the undergraduate training has been in a discipline other than engineering. Supporting work will be required depending on the student's background and area of interest with requirements defined by departmental guidelines.

For the degree Doctor of Philosophy the foreign language requirement, or a substitute, may be satisfied in one of three ways: (1) Demonstrate a communication competence (ETS score of 600 or 6 credit hours of 200 level) in one foreign language approved by the program-of-study committee. (2) Demonstrate a proficiency in FORTRAN computer language by course work (6 hours above Com S 172) or special examination. (3) Complete a minimum of 6 credits of additional course work not directly related to the major or minors. These courses are intended for the cultural enrichment of the student and are subject to the approval of the program of study committee.

The department also participates in the interdepartmental minor program in Energy Systems Engineering and in the interdepartmental programs in Technology and Social Change and Water Resources (see Index).

Courses for Graduate Students, minor only

342. Agricultural Tractor Power. (2-3) Cr. 3. S. *Prereq: M. E. 330.* Thermodynamic principles and construction of tractor engines. Fuels, combustion, and lubrication. Kinematics and dynamics of tractor power applications; drawbar, power take-off and traction mechanisms. Fee for field trips.

371. Agricultural Structures. (2-2) Cr. 3. F. *Prereq: 201, E M 324.* Structural analysis and design of agricultural buildings. Analysis of materials, design loads, and timber and concrete design.

421. Hydraulic Design of Soil and Water Control Facilities. (2-3) Cr. 3. F. *Prereq: Credit or classification in E M 378.* Application of open channel flow principles to the design of irrigation, drainage and erosion control facilities. Hydraulics of conduits and stilling basins. Hydraulics of pumps. Spatially varied flow. Flow through porous media.

422. Drainage and Irrigation Engineering. (2-3) Cr. 3. S. *Prereq: 202, E M 378, Fr E 155L.* Theory of subsurface drainage. Design of surface and subsurface drainage systems. Design of field irrigation application systems. Use of computers in solving soil and water conservation problems. Fee for field trip.

443. Agricultural Machinery Design I. (2-3) Cr. 3. F. *Prereq: 202, Fr E 155L, E M 345.* Analysis of existing agricultural machines and identification of the new or improved machines. Establishment of functional performance, reliability and safety goals. Design of an agricultural machine or component to meet established goals.

444. Agricultural Machinery Design II. (0-6) Cr. 2. S. *Prereq: 443.* Construction, testing, and evaluation of a machine or component designed in 443.

447. Power and Control Hydraulics. (1-3) Cr. 2. F. *Prereq: Credit or classification in E M 378.* Properties of hydraulic fluids. Performance parameters of fixed and variable displacement pumps and motors. Characteristics of control valves. Analysis and design of hydraulic systems for power and control functions. Fee for field trips.

463. Electrical Energy Application in Agriculture. (2-2) Cr. 3. F. *Prereq: E E 441.* Farm lighting and wiring system design. Electric motor characteristics and applications. Electrical safety. Electrical controls in agriculture. Standby power systems.

469. Processing, Handling, and Storage of Agricultural Materials. (3-3) Cr. 4. S. *Prereq: 202.* Principles of preservation by drying, chemical treatments, and oxygen-limiting techniques. Fan applications. Material handling and processing. Physical properties of biological materials. System design. Fee for field trip.

471. Principles of Livestock Waste Management. (3-0) Cr. 3. F. *Prereq: Chem 167, E M 378.* Principles of chemistry, bacteriology, and engineering applied to the collection, treatment, and further use of animal wastes.

472. Environmental Engineering for Agricultural Structures. (2-0) Cr. 2. S. *Prereq: 201, M E 330.* Principles of animal environment. Analysis and design of environmental control systems. Insulation, ventilation, air distribution, heating and cooling systems, and controls.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501. Agricultural Resources Engineering. (3-0) Cr. 3. F. *Prereq: One 400 level A E course.* Role of the engineer in agricultural resource development. Land and water resource development. Issues and restraints in agricultural technology. Research priorities, evaluation and support. Literature searches and project development.

502. Simulation of Agricultural Systems. (3-0) Cr. 3. S. *Prereq: Math 160, Com S 172, Stat 401.* Model development and computer simulation of processes and systems in agriculture. Model elements include soil, crop, animal and machine parameters. Interdisciplinary applications.

523. Erosion and Sediment Transport. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: Math 266 and one of the following: 421, Geol 377, Agron 577.* Erosion processes. Initiation of motion and overland flow. Erosion models. Flow in alluvial channels and theory of transport. Surface soil and channel stability. Wind erosion.

563. Advanced Electrical Energy Applications in Agriculture. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 463.* Electrical energy use in agriculture. Research in agriculture electrification. Instrumentation methods.

569. Advanced Crop Conditioning and Storage. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 469, Fr E 155L.* Computer simulation of grain drying. Grain deterioration. Non-linear airflow through grain. Research in crop conditioning and storage.

572. Advanced Design of Agricultural Building Systems. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 471, 472.* Animal environmental control equipment; air distribution; optimization of thermal constraints; research instrumentation; solar energy; bulk storage of granular materials; manure management using anaerobic digestion; energy budgets for digesters; flow properties of manure slurries.

590. Special Topics. Cr. 1 to 3.
B. Mechanization
N. Crop Conditioning and Storage
P. Power and Machinery
Q. Structures and Environment
R. Electric Power and Processing
S. Soil and Water
T. Construction and Maintenance
U. Waste Management

Courses for Graduate Students, major or minor

646. Soil Dynamics. (1-2) Cr. 2. Alt. S., offered 1983. *Prereq: E M 324, Agron 577 or C E 360.* Stress-strain relationships in soils subjected to dynamic loads. Pull-slip-sinkage relationships of traction devices. Interaction of tillage energy and compactive energy.

648. Harvesting Machines. (1-2) Cr. 2. Alt. S., offered 1982. *Prereq: 443, 501.* Principles of cutting, gathering, threshing, and separating. Analysis of harvesting devices. Effects of crop condition, maturity, and moisture content on performance of functional components.

661, 662. Seminar. (1-0) Cr. 1 each. Yr. Discussion of research problems, methods, procedures, and reports.

690. Advanced Topics. Cr. var.

699. Research
B. Mechanization
N. Crop Conditioning and Storage
P. Power and Mechanization
Q. Structures and Environment
R. Electric Power and Processing
S. Soil and Water
U. Waste Management

Agricultural Mechanization

Administered by the Department of Agricultural Engineering

H. P. Johnson, Professor in Charge

The Department of Agricultural Engineering offers courses for minor graduate credit in agricultural mechanization for students taking major work in other departments.

Courses for Graduate Students, minor only

424. Drainage and Irrigation Management. (3-0) Cr. 3. S. *Prereq: 324.* Development of knowledge in drainage and irrigation of agricultural lands, interaction of agencies involved, and relationships to water use and control in agricultural production. Fee for field trip.

430. Farm Machinery Principles and Mechanisms. (2-3) Cr. 3. Alt. S., offered 1982. *Prereq: 330, 335, Phys 111.* Principles of operation of agricultural machines. Study of mechanisms, forces, and strengths of machinery. Safety considerations in agricultural machinery.

435. Agricultural Safety. (1-3) Cr. 2. F. *Prereq: 250, 330, 360.* Risk recognition hazard analysis and danger evaluation in the agricultural industry. Epidemiological study of accidents. Product reliability, safe design and operation.

440. Intermediate Technology. (1-3) Cr. 2. S. *Prereq: 9 credits of agricultural sciences.* The philosophy and use of intermediate technology in developing countries. Design parameters, plans, and specifications of equipment. Case studies of appropriate technology.

450. Construction of Agricultural Structures. (1-4) Cr. 2. F.S.SS. *Prereq: 250.* A combination of construction techniques and selected experiences associated with various types of agricultural structures: conventional frame, pole, rigid frame, unitized, and concrete and masonry construction.

462. Advanced Crop Conditioning and Handling Systems. (2-0) Cr. 2. Off campus, offered as requested. *Prereq: 362.* Grain drying and high-moisture preservation methods. Psychrometrics. Fans and airflow. Material handling methods. Computer simulation of grain drying. System planning. Designed for Master of Agriculture Program.

474. Livestock Housing Systems. (2-0) Cr. 2. Off campus, offered as requested. *Prereq: 6 credits of agricultural or biological science.* Properties of moist air, effects of environment on animal performance, principles of environmental control, feed handling systems, manure management alternatives, planning total systems. Designed for Master of Agriculture Program.

475. Waste Management for Livestock Production Systems. (2-0) Cr. 2. S. *Prereq: 6 credits of biological sciences, 3 credits of math.* Introduction to the quantitative aspects of manure management, pollution and disease hazards. Measurements of pollution. Design of storage structures and lagoon systems.

476. Farmstead Planning. (1-2) Cr. 2. S. *Prereq: 273 or 473.* Layout and organization of farmsteads. Planning farm homes, livestock production buildings, structures for crop storage and machinery housing. Plans, construction materials, and structural considerations for agricultural buildings.

485. Advanced Metal Construction and Maintenance. (1-4) Cr. 2. S. *Prereq: 285, junior classification.* Problems related to materials selection and welded metal construction from shop drawings. Lab fee.

488. Teaching Agricultural Mechanics. (2-4) 8 weeks. Cr. 2. F.S. *Prereq: 250, 285.* Organization and management of the agricultural mechanics instructional program, facility and equipment. Students plan and present demonstrations of teaching agricultural mechanics skills.

489. Developments in Agricultural Mechanics. (2-2) Cr. 1. F.S.SS. Off-campus 5 weeks. *Prereq: 488.* Selection, principles of operation, application and maintenance of equipment and materials used in mechanized agriculture. Development of instructional units for vocational-technical programs.
A. Electricity in Agriculture
B. Electric Motors
C. Agricultural Structures
D. Metal Construction
E. Agricultural Machinery
F. Hydraulics in Agriculture
G. Diesel Tractors

490. Independent Study. Cr. 1 to 5.
H. Honors
P. Power and Machinery
Q. Structures and Environment
R. Electric Power and Processing
S. Soil and Water
T. Construction and Maintenance

493. Engineering Principles for Food Technology I. (F Tch 493) See *Food Technology*.

494. Engineering Principles for Food Technology II. (F Tch 494) See *Food Technology*.

Agronomy

John Pesek, Head of Department

The Graduate Faculty

Members: Amemiya, I. C. Anderson, M. A. Anderson, Atkins, Black, Bremner, Browning (Emeritus), Burris, I. T. Carlson, R. E. Carlson, Dumenil, Fehr, Frey, Green, Hallauer, Hanway, Hodges, Kirkham (Emeritus), Palmer, Pearce, Pesek, Peterson, Pierre (Emeritus), Riecken (Emeritus), Russell, Sadanaga, Scholtes, Scott, Shaw, Shibles, Tabatabai, H. M. Taylor, L. M. Thompson, Webb, Wedin, Woolley, Yarger

Associate Members: Bhella, Blackmer, Crosbie, Cruse, Fenton, George, Loynachan, Miller, Mullen, Smith, Takle, S. E. Taylor, Troeh, Vaughan, Voss, Whigham

The department offers work for the degrees of Master of Science and Doctor of Philosophy, with majors in crop production and physiology, plant breeding and cytogenetics, soil physics, soil chemistry, soil fertility, soil microbiology and biochemistry, soil morphology and genesis, soil management, and agricultural climatology. Minor work is provided for students with majors in other departments. An M.S. nonthesis option is available for students desiring to pursue a special project not involving thesis research.

The M.S. nonthesis requirement is completion of 34 hours of graduate credit, which must include 4 hours of creative component (Agron 599), submission and approval of a report on the special project undertaken, and satisfactory completion of a final oral examination.

The department also cooperates in the interdepartmental programs of Immunobiology; Molecular, Cellular and Developmental Biology; Technology and Social Change; and Water Resources. (See *Index*.)

Prerequisite to major work in this department is completion of an undergraduate degree program with emphasis on biological and physical sciences. The foreign language requirement, if any, for the Ph.D. degree is established on an individual basis by the advisory committee appointed to guide the work of the student.

Courses for Graduate Students, minor only

318. Principles of Crop Physiology. (3-0) Cr. 3. F.S. *Prereq: Bot 310 or 320.* Pearce. Basic principles concerning the growth, development, and production of crop communities in relation to their environment.

354. Soil Fertility (2-3) Cr. 3. F.S. Alt SS., 1982. *Prereq: 154, 2 chemistry courses.* Troeh or Loynachan. Chemical, biological, and physical properties of soils in relation to plant growth and development. Nutrient behavior in the soil. Fertility evaluation. Principles guiding use of lime, manure, and fertilizers.

364. Soil Resource Conservation. (2-3) Cr. 3. S. *Prereq: 154 or 357.* Troeh. Relation of soil properties and land morphology to erosion. Principles and methods of conserving soil. Preparation of a land-use plan. Out-of-town field trips. Fee charged for field trips.

406. Climate of the Continents. (Mteor 406) (2-0) Cr. 2. S. *Prereq: Agron Mteor 206.* Shaw. The major climate controls and how they affect the world climate. Climate classification. Combining controls and classification to explain the pattern of climates of the different continents and the world.

412. Crop Management. (2-0) Cr. 2. F.S. Woolley. *Prereq: 212; junior or senior classification.* Synthesis of crop management systems and practices using the principles of agronomic science. Field crops commonly grown in the midwestern U.S. serve as a basis for grain crop management situations.

415. World Crops. (3-0) Cr. 3. F. Whigham. *Prereq: 114.* Origin, characteristics, adaptation, production, and products of economically important crops of the world with emphasis on crops not commonly grown in the midwestern U.S.

421. Introduction to Plant Breeding. (3-0) Cr. 3. F.S. *Prereq: Gen 320.* Green. Basic principles used in genetic improvement of plants. A review of genetics and reproduction as related to plant breeding. Methods of breeding self-pollinated, cross-pollinated, and asexually reproducing plants.

453. Fertilizers. (2-0) Cr. 2. F.S. *Prereq: 354.* Stritzel. Manufacture, agronomic use, and environmental impact of fertilizers. Agronomic utilization of macro- and micro-nutrients as related to physical and chemical properties of soils, crop needs, and economic profitability.

454. Soil Management. (2-0) Cr. 2. F.S. *Prereq: 212 or 354.* Stritzel. Integrating principles of soil science and economics into soil management programs. Primary emphasis on tillage, soil and tissue testing, lime and fertilizer use, soil-air-water relationships, and organic, sandy, and forest soil management.

457. Soil Chemistry and Physics. (2-0) Cr. 2. S. *Prereq: 354.* Troeh. Chemical, physical, and mineralogical properties of soils. Influence of particle size and mineralogy on soil properties. A study of the colloidal system and the movement of materials in soils.

473. Soil Genesis and Survey. (2-3) Cr. 4. F.S. *Prereq: 154 or 357.* Scholtes. Development, characteristics, and identification of soils; study of soil profiles and soil landscapes; soil classification systems, theory and practice of soil mapping; interpretation of soil survey information; two 2-day field trips. Fee for field trips.

483. World Soil Resources. (2-0) Cr. 2. S. *Prereq: Chem 163 (154 recommended).* Schafer. Properties, classification and geographic distribution of soils with emphasis on their suitability for food prodution.

485. Soil Biology. (Micro 485). (2-3) Cr. 3. F. *Prereq: 154, Micro 300.* Loynachan. Description of organisms in the soil and plant environment, and their role in organic matter decomposition (including natural materials and man-made chemicals and wastes), nitrogen fixation and transformations, and other processes which directly or indirectly affect people.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Orientation Seminar. (2-0). Cr. 1. F. *Prereq: Graduate classification in agronomy, and from foreign country.* Pesek and staff. An introduction to Iowa and U.S. agriculture for international scholars. Field trips when possible. Departmental role in the functioning of research, teaching, and extension in fulfilling the charge given the land-grant university.

505. Microclimatology. (Mteor 505). (3-0) Cr. 3. S. *Prereq: Agron Mteor 206.* Shaw. The heat exchange near the ground. Radiation, turbulence, conductance and evaporation as components of the heat balance. Temperature, wind and humidity conditions in the microclimate. Modification of the microclimate.

514. Crop Plant Ecology. (3-0) Cr. 3. F. *Prereq: 318, Gen 320.* Crosbie. Principles and concepts of origin, evolution, adaptation, and distribution of world crops. Genetic and physiological aspects of crop plant behavior in natural and agro-ecosystems.

516. Crop Physiology and Management. (2-0 or 3-0) Cr. 2 or 3. S. *Prereq: Bot 320.* Shibles, Anderson. Physiology of crop growth, development, and productivity. Application of physiological and ecological principles to crop culture and management. Students may elect physiology only (10 wks, 2 cr.) or the full topic (15 wks, 3 cr.)

521. Intermediate Plant Breeding. (3-0) Cr. 3. S. *Prereq: 421; Stat 401.* Fehr. Analysis of alternative breeding methods for improvement of crop plants. Strategies for hybridization and self-pollination. Sterility systems and their relationship to breeding methods and commercial hybrid seed production.

522. Field Methods in Plant Breeding. (0-6) Cr. 2. SS. *Prereq: 521.* Field experience in planning and conducting plant breeding research for cross-pollinated and self-pollinated crops. Offered on a satisfactory-fail basis only. Fee for field trips.

529. Cytogenetics in Plant Breeding. (2-2) Cr. 3. Alt. F., offered 1981. *Prereq: 521; Gen 501, 625.* Peterson. Chromosome recombination, principles of chromosome pairing, gene distribution within the genome, aberrations, polyploids, genome relations, aneuploids, nullisomic analysis, interspecific hybrids, cell fusion, evolution of the nucleotype, repetitive DNA, the eukaryotic genome, and emergent techniques for the genetic improvement of crops.

534. Forages: Management and Utilization. (2-0) Cr. 2. F. *Prereq: 212; An S 319.* Wedin. Forage (machine harvested and grazed) principles and practices leading to economic utilization systems. Emphasis on soil-plant-animal relationships under grazing and role of ruminants as forage converters.

541. Agricultural Climatology. (2-0) Cr. 2. Off campus, offered as requested. *Prereq: 206.* Basic concepts in agriculture climatology with emphasis on the weather-agriculture relationship and the microclimate-agriculture interaction. Designed for the Master of Agriculture Program.

542. Advanced Crop Management. (2-0) Cr. 2. Off campus, offered as requested. *Prereq: 318 or 412.* Staff. Basic concepts in plant-soil-climate relationships with emphasis on recent advances in crop culture and management. Designed for the master of agriculture program.

551. Growth and Development of Perennial Grasses. (Hort. 551). See *Horticulture*.

553. Soil-Plant Relationships. (2-0) Cr. 2. F. *Prereq: 354.* Blackmer. Composition and properties of soils in relation to the nutrition and growth of plants.

554. Soil Environment-Root Relationships. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 354; Math 165 or 175.* Cruse. Implications of tillage practices on the soil environment and root activity. Effect of soil physical properties on soil erosion.

558. Laboratory Methods in Soil Chemistry. (2-3) Cr. 3. F. *Prereq: Chem. 211.* Tabatabai. Experimental and descriptive inorganic and organic analysis. Operational theory and principles of applicable instruments, including spectrophotometry, atomic and molecular absorption and emission spectroscopy, mass spectrometry, X-ray diffraction and fluorescence, gas and ion chormatography, and specific-ion electrodes.

561. Irrigation Agriculture. (2-0) Cr. 2. F. *Prereq: 354.* Troeh. Properties of soils in relation to irrigation; use and quality of irrigation water; reclamation of saline and sodic soils; management of irrigated cropland; irrigation in humid regions.

575. Soil Morphology, Genesis and Classification. (3-0) Cr. 3. F. *Prereq: 473, 553.* Morphology and formation of soils, systems of classification and geographical distribution of soils.

577. Soil Physics. (2-0) Cr. 2. F. *Prereq: 354; Math 166 recommended.* Relation to physical properties of soils to plant growth, particle size distribution, soil structure, clay minerals, soil moisture, soil air, and soil temperature.

578. Laboratory Methods in Soil Physics. (1-3) Cr. 2. S. *Prereq: 577.* Methods of measuring soil physical properties such as texture density, and water content, and transport of heat, water and gases.

585. Soil Microbiology and Biochemistry. (Micro 585). (2-3) Cr. 3. S. *Prereq: 485, one course in biochemistry.* Loynachan. Concepts and methods in dynamics and ecology of soil microorganisms, organic matter formation, enzymatic systems, and carbon and mineral cycles.

590. Special Topics. Cr. arr. *Prereq: 15 credits in agronomy.* Literature reviews and conferences on selected topics in crops, soils, or climatology according to needs and interest of student.

599. Creative Component. Cr. arr. *Prereq: Nonthesis M.S. option only.* A written report based on research, library readings, or topics related to the student's area of specialization and approved by the student's advisory committee.

A. Agricultural Climatology
B. Crop Production and Physiology
C. Plant Breeding and Cytogenetics
D. Soil Chemistry
E. Soil Fertility
F. Soil Management
G. Soil Microbiology and Biochemistry
H. Soil Morphology & Genesis
I. Soil Physics

Courses for Graduate Students, major or minor

600. Seminar. (1-0) Cr. 1. Reports and discussion of recent literature research.

A. Crops. F.S. Carlson or Hallauer.
B. Soils. F.S. Staff
C. Soil-Plant-Climate. F.S. Staff

609. Agricultural Climatology Conference. (0-1) Cr. 1. F.S.SS. *Prereq: Permission of instructor.* Carlson, Shaw. Literature reviews and conferences with instructor on special problems relating to agricultural climatology, beyond the scope of current courses offered.

616. Advanced Topics in Crop Physiology and Biochemistry. (4-0) Cr. 4. S. *Prereq: 516; Bot 511, 512, 513; permission of instructor.* Anderson, Shibles. An in-depth treatment of physiological and biochemical processes and their relationships to crop growth and development. Emphasis is placed on individual study followed by in-class discussion.

619. Professional Development in Crop Production and Physiology. (1-0) Cr. 1. Alt. F., offered 1981. *Prereq: Permission of instructor.* Shibles, Wedin. The organization of agricultural research in the United States; instruction and practice in research proposal preparation, writings of professional papers, and presentation of papers at national meetings; organization and teaching of university-level courses; advising graduate students; the extension education career; ethics in science; vita preparation; interview interaction; other professional-related topics.

620. Colloquium in Crop Production and Physiology. (1-0) Cr. 1. F.S. *Prereq: Permission of instructor.* Anderson. Presentation of papers and informal discussion of related literature topics in crop physiology and crop production.

621. Advanced Plant Breeding. (3-0) Cr. 3. S. *Prereq: 521, Stat 436, Gen 501.* Russell. Heritability, estimation of genetic effects and genetic advance; inbreeding depression and heterosis; development of parental materials; prediction of hybrid and synthetic performance; general and specific combining ability; procedures and problems in progeny evaluation.

625. Population Development and Utilization in Plant Breeding. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 521, Stat 436, Gen 501.* Frey. Natural systems of reproduction and their consequences in crop

improvement. Methods for generating genetic variation, including the use of exotic germplasm and interspecific hybridization. Populations in plant breeding strategies. Characteristics of cultivar populations relative to agricultural production.

629. Colloquium in Plant Breeding and Cytogenetics. (1-0) Cr. 1. Alt. S., offered 1982. *Prereq: Permission of instructor. Peterson. Presentation* of papers and informal discussion of related literature in plant breeding and cytogenetics.

634. Research Methods for Pasture and Forages. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 534, Stat 401.* Wedin. Study of appropriate pasture and forage intake: quality assessment in studies dependent on animal effects. Adaptation of methods to grassland development situations. Considerations of forage economics and system analyses. Student reports on current research literature.

655. Advanced Soil Fertility. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 553.* Evaluation of soil fertility and fertilizers; theory and applications.

657. Advanced Soil Chemistry. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 553, Chem 321. Scott.* Structural and surface chemistry of soil clay minerals.

675. Advanced Soil Genesis and Classification. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 575.* Fenton. Processes, reactions, and theories in soil formation; principles of soil classification.

677. Advanced Soil Physics. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 577, Math 266; 267 recommended.* The flow and distribution of water, gas, and heat in soils. Physical principles and applications.

685. Advanced Soil Biochemistry. (Micro 685) (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 585.* Bremner. Nature of soil organic matter and biochemical transformations brought about by soil microorganisms.

699. Research.
A. Agricultural Climatology
B. Crop Production and Physiology
C. Plant Breeding and Cytogenetics
D. Soil Chemistry
E. Soil Fertility
F. Soil Management
G. Soil Microbiology and Biochemistry (Micro 699)
H. Soil Morphology and Genesis
I. Soil Physics

Animal Ecology

Robert C. Summerfelt, Chair of Department

The Graduate Faculty

Members: Atchison, R. W. Bachmann, Best, Carlander, Dahlgren, Dinsmore, Klaas, Menzel, Summerfelt

Associate Members: M. D. Bachmann, Clark, Franklin, Hubert, Moorman, Nickum

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in animal ecology, fisheries biology, and wildlife biology. Within these majors, the student may also specialize in animal behavior, ecology, limnology, or taxonomy.

The Ph.D. degree requires proficiency in one foreign language. This may be demonstrated by one year of college credit with a minimal average of 2.0 (on a 4.0 = A scale), by an Educational Testing Service Foreign Language Examination score of at least 500, or by committee approval of equivalent language experience. The student's committee may require additional language competence.

Personnel of the U.S. Fish and Wildlife Service, through the Iowa Cooperative Fishery and Wildlife Research Units, and the Iowa State Conservation Commission contribute to the graduate program of the department. The department participates in the interdepartmental graduate program in Water Resources (see Index).

No more than two dual-listed animal ecology courses may be applied for major graduate credit.

Courses for Graduate Students, minor only

350. Wildlife Techniques and Habitat Analysis. (1-3) Cr. 2. S. *Prereq: 231, 320L.* Techniques and methods used in research and management of wildlife with emphasis on inventory and manipulation of wildlife populations and habitat. Field trips.

410. Limnology. (2-0) Cr. 2. F. *Prereq: 10 credits in biological sciences or graduate classification.* Structure and function of aquatic ecosystems with application to fishery and pollution problems.

440. Fishery Management. (2-0) Cr. 2. F. *Prereq: 231, 320L.* Biological basis of fishery management.

441. Fishery and Limnological Techniques. (0-6) Cr. 2. F. *Prereq: Credit or classification in 410 or 440 or 510.* Field and laboratory methods used in fishery and limnological studies. Field trips.

451. Wildlife Management. (2-3) Cr. 3. F. *Prereq: 312, 350.* Basic principles of managing wildlife populations. Fee for field trips.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Seminar. (2-0) Cr. 1 each time taken; may be taken more than once for graduation credit. F.S. *Prereq: Permission of instructor or graduate classification.* Current topics in ecological research, fish and wildlife management, and environmental problems related to fish or wildlife resources. Fee charged for sections requiring field trips.

510. (410 DL). Limnology. (2-0) Cr. 2. F. *Prereq: 10 credits in biological sciences.* Graduate study in conjunction with 410. Additional work required for graduate credit. Not available for credit for students having taken 410.

511. Population Ecology. (3-0) Cr. 3. S. *Prereq: 312; Stat 401; a course in calculus.* Theories and concepts of animal population dynamics and regulation with emphasis on the analysis of biological populations.

512. Vertebrate Behavioral Ecology. (Zool 512) (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 312; Zool 304 recommended.* Selected topics in behavior considered relative to environmental influences and ecological concepts. Includes predation, foraging, spacing, reproduction, and habitat selection.

513. Pollution Ecology. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 312.* Ecological relationships between aquatic and terrestrial organisms and environmental pollutants. Aspects of source, occurrence, persistence, toxicity, ecosystem dynamics, and rate of degradation of pollutants.

514. Evolutionary Ecology. (4-0) Cr. 3. S. *Prereq: 312; Biol 303, Gen 320 recommended.* Relationships between animals and their environment, with major emphasis on adaptive strategies and evolutionary mechanisms.

520. Fish Ecology. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 312, 321.* Ecological interrelationships of fish communities in North American lakes and streams. Emphasis on habitat and reproductive ecology, and community structure.

521. (321 DL) Ichthyology. (2-4) Cr. 4. S. *Prereq: 320L.* Graduate study in conjunction with 321. Additional work required for graduate credit. Not available for credit for students having taken 321.

522. (322 DL) Herpetology. (2-3) Cr. 3. Alt. S., offered 1982. *Prereq: 320L.* Graduate study in conjunction with 322. Additional work required for graduate credit. Not available for credit for students having taken 322.

523. (323 DL) Mammalogy. (2-6) Cr. 4. F. *Prereq: 320L.* Graduate study in conjunction with 323. Additional work required for graduate credit. Not available for credit for students having taken 323.

524. (324 DL) Ornithology. (1-3) Cr. 2. S. *Prereq: 320L.* Graduate study in conjunction with 324. Additional work required for graduate credit. Not available for credit for students having taken 324.

531. Wildlife Planning, Policy, and Administration. (3-0) Cr. 2. Alt. F., offered 1981. *Prereq: A course in natural resource management.* History and philosophy of wildlife administration, and modern methods for planning and implementing management policy. Intended for students interested in employment in public or private agencies dealing with natural resources.

541. Fish Culture. (2-3) Cr. 3. Alt. S.. offered 1983. *Prereq: 231, 320L.* Principles and techniques of fish propagation, hatchery operation, nutrition, and disease problems. Fee charged for field trips.

543. Advanced Fishery Management. (2-3) Cr. 3. F. *Prereq: 321, 410, 440, 441.* Survey and evaluation of principles and techniques used in research and management of fishery resources. Fee charged for field trips.

551. Wildlife Sociobiology and Management. (2-2) Cr. 3. Alt. S., offered 1982. *Prereq: 312; a course in wildlife management recommended.* Examination and synthesis of social organizational and behavioral concepts important for wildlife management. Game and non-hunted wildlife species of the world treated.

590. Special Topics. Cr. arr. F.S.SS. *Prereq: Graduate classification, permission of instructor.*

Courses for Graduate Students, major or minor

600. Seminar. (2-0) Cr. 1 each time taken. F.S. Current topics in ecological research, fish and wildlife management, and environmental problems related to fish or wildlife resources. Fee charged for sections requiring field trips.

610. Advanced Limnology. (2-3) Cr. 3. S. *Prereq: 410 or 510, 441; Stat 401.* Physical, chemical, and biological processes of lakes and streams and their relationships to biological productivity, ecological succession, and water quality. Limnological research techniques. Field trips.

640. Fishery Resources and Research Techniques. (3-3) Cr. 4. Alt. F., offered 1982. *Prereq: 440; Stat 401.* Major fishery resources and how they have been studied and managed. Critical analysis.

650. Advanced Wildlife Management. (3-3) Cr. 4. Alt. F., offered 1982. *Prereq: 451.* Advanced treatment of ecology and management of upland birds and mammals, ungulates, large carnivores, shorebirds, waterfowl, and selected furbearers. Fee charged for field trips.

699. Research

*Courses Offered at the Iowa Lakeside Laboratory

302L. Field Biology. (4-12) Cr. 3. SS. Animals in the field, with particular emphasis on their recognition and on collecting, preserving, and laboratory culture methods. Field trips. Must be taken concurrently with Bot 301L.

508L, 509L. Aquatic Ecology. (8-24) Cr. 5 each. SS. Survey of local aquatic organisms and aquatic habitats; analysis of physiographic, physical, and chemical factors. Emphasis on field work, methodology, and basic ecological principles. Field trips.

**Courses Offered at the Gulf Coast Research Laboratory, Ocean Springs, Mississippi.

412G. (ZO 452) Marine Ecology. Cr. 4. *Prereq: Courses in general botany, invertebrate zoology and analytical chemistry.* A consideration of the relationship of marine organisms to their environment, including the effects of temperature, salinity, light, nutrient concentration, currents, and food on their abundance and distribution.

442G. (ZO 442) Marine Fisheries Management. Cr. 4. A general course in fisheries management designed to acquaint students with the philosophy, objectives, problems, and principles involved in management decisions. Lectures will include specialists in biology, fisheries statistics, sanitation, and marine law.

*Written permission of the instructor is prerequisite to all courses offered at the Iowa Lakeside Laboratory. For current information concerning courses, registration, and housing, see the annual Iowa Lakeside Laboratory Bulletin. This bulletin is usually available from participating departments after February 15.

**Written permission of the coordinator of the Gulf Coast Research Laboratory, 201 Bessey Hall, Iowa State University, Ames, Iowa, 50011, is prerequisite to all courses offered at the Laboratory. Numbers beginning with ZO are GCRL numbers. Courses offered may vary from year to year.

443G. (ZO 464) Marine Aquaculture. Cr. 6. *Prereq: general zoology or invertebrate zoology.* A lecture, laboratory, and field course designed to introduce aquatic and marine biology students to the history, principles, problems, and procedures relating to the culture of commercially important crustaceans, fish, and mollusks along the Gulf Coast.

Animal Science

S. A. Ewing, Head of Department

The Graduate Faculty

Members: Anderson, Beitz, Berger, Burroughs, Ewan, Ewing, Ford, Foreman, Freeman, Hoffman, Jacobson, Kline, Lush, McGilliard, Melampy, Nordskog, Olson, Owings, Parrish, Robson, Rothschild, Sebranek, Self, Sell, Speer, Stromer, Trenkle, Wiggers, Willham, Young, Zimmerman

Associate Members: Brackelsberg, Christian, Hasiak, Jurgens, Kenealy, Rust, Spike, Wunder

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in animal breeding, animal nutrition, meat science, muscle biology, nutritional physiology, poultry nutrition, poultry products technology, physiology of reproduction, and molecular, cellular and developmental biology. Minor work is offered in these areas to students taking major work in other departments. For students desiring more general training, the degree Master of Science is offered in animal production. In this program, additional course work may be substituted for a thesis.

A strong undergraduate program is required for those students interested in graduate study. Fundamental training in biology, chemistry, mathematics, and statistics is requisite to a satisfactory graduate program. Graduate programs in animal science include supporting work in areas such as agronomy, anatomy, bacteriology, biochemistry, chemistry, economics, food technology, genetics, physiology, and statistics. Students may choose graduate programs involving a co-major with one of these areas. Graduate work in meat science is offered as a co-major in animal science and food technology.

The department also cooperates in the interdepartmental program of Immunobiology. (See *Index*.)

The foreign language requirement, if any, is established on an individual basis by the program-of-study committee appointed to guide the work of the student.

Courses for Graduate Students, minor only

318. Fundamentals of Nutrition. (3-0) Cr. 3. F.S.SS. *Prereq: Organic chemistry or B B 221; physiology recommended; junior classification.* Digestion and metabolism of carbohydrates, fats, proteins, minerals, and vitamins. Measures of energy.

319. Applied Animal Nutrition. (3-0) Cr. 3. F.S.SS. *Prereq: 318.* Essential nutritive requirements of livestock and poultry, sources and composition of nutrients, replacement value of feeds in rations, ingredient value of feeds in rations, ingredient identification, ration formulation, and feeding recommendations. Credit for both 218 and 319 may not be applied toward graduation.

331. Animal Reproduction and Lactation. (3-0) Cr. 3. F.S. *Prereq: Course in physiology.* Comparative anatomy, physiology, and endocrinology of animal reproduction and lactation.

352. Livestock Improvement Through Animal Breeding. (3-2) Cr. 4. F.S.SS. *Prereq: Course in genetics recommended.* The genetic and environmental bases of animal differences. Selection and mating systems as mechanisms for genetic change. Designing breeding programs for economically important traits. Selection in a simulated breeding herd.

353. Designing Breeding Programs for Livestock. (1-2) Cr. 2. F. *Prereq: 352; Course in genetics.* Evaluation of alternate breeding programs. Multiple trait selection. Merchandizing seedstock. Computerized simulation and management decision aids. Fee for field trips.

360. Meat Animal Growth and Body Composition. (2-2) Cr. 3. F.S. *Prereq: 214, Biol 110, B B 221 or organic chemistry.* Prenatal and postnatal development of animal and poultry tissue with emphasis on muscle, fat and bone growth. Evaluation of body composition for meat-producing animals. Grades and pricing.

370. Meat Science and Processing. (2-2) Cr. 3. F.S. *Prereq: 360.* Physical, chemical, and biological conversion of muscle to meat. Fundamentals involved in meat processing and preservation. Techniques utilized for improving and maintaining high quality meat products for distribution and consumption. Fee for field trips.

415. Horse Production. (2-2) Cr. 3. S. *Prereq: 319 or 218, 352.* Principles and concepts of horse genetics, breeding, reproduction, nutrition, behavior, training, stable management, and marketing. Application of these concepts in pleasure horse production and use. Fee for field trips. Lab fee.

420. Poultry Nutrition. (2-2) Cr. 3. F. *Prereq: 319.* Theoretical and practical aspects of poultry nutrition. Ration formulation, mixing, and feeding tests. Feeding programs and requirements at different ages.

423. Poultry Production. (2-2) Cr. 3. S. *Prereq: 319 or 218, 352.* Practical feeding and management of chicken and turkey flocks. Operational study of commercial farms, including production and marketing practices. Fee for field trips.

425. Pork Production. (2-2) Cr. 3. F.S. *Prereq: 319 or 218, 352.* Life-cycle swine production. Fee for field trips.

427. Beef Production. (2-2) Cr. 3. F.S. *Prereq: 319 or 218, 352.* The beef industry. Principal emphasis on cow-calf operations. Postweaning production systems. Fee for field trips.

428. Cattle Feedlot Management. (2-2) Cr. 3. F. *Prereq: 319, 352, 360.* Preconditioning, selection and handling, climatic control and seasonal influences, facilities, waste management, health and diseases, nutrition and feeding programs, production costs, marketing and carcass evaluation. Fee for field trips.

429. Lamb and Wool Production. (2-2) Cr. 3. S.SS. *Prereq: 319 or 218, 352.* Calendarized farm flock program. Programs for feeder lambs. Fee for field trips.

434. Milk Production. (3-0) Cr. 3. F.S. *Prereq: 319 or 218.* Economics of milk production. Facilities, feeding, management of the milking herd. Nutritional relationships in milk secretion. Raising herd replacements.

436. Dairy Enterprise Planning. (2-2) Cr. 3. S. *Prereq: 434.* Independent student and team development of dairy production systems, cost analysis, budgets, and labor requirements. Fee for field trips.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

500. Computer Techniques for Biological Research. (2-2) Cr. 3. S. *Prereq: Stat 401.* Development of computing strategies for problem solving. Constructing algorithms and organizing data for statistical program libraries.

503. Seminar in Animal Production. (1-0) Cr. 1. F. *Prereq: Permission of instructor.* Discussion and evaluation of current topics in animal production and management.

505. Techniques in Animal Nutrition Experimentation. (2-3) Cr. 3. S. *Prereq: Stat 401.* Planning, execution, interpretation, and communication of nutrition research.

510. Applied Animal Breeding. (2-0) Cr. 2. Off campus, offered as requested. *Prereq: 352.* Principles of animal breeding; application to improvement of domestic animals. Heritability, genetic and phenotypic correlations, selection indexes, sire and dam evaluation, and breeding program design. Designed for Master of Agriculture Program only.

511. Applied Ruminant Nutrition. (2-0) Cr. 2. Off campus, offered as requested. *Prereq: 319.* Procedures and theories in beef, dairy, and sheep nutrition. Feeding programs and requirements for lactation, growth, and reproduction. Designed for Master of Agriculture Program only.

512. Applied Non-Ruminant Nutrition. (2-0) Cr. 2. Off campus, offered as requested. *Prereq: 319.* Recent developments and application of basic nutritional concepts for swine and poultry production. Selected aspects and concepts of computer diet formulation. Designed for Master of Agriculture Program only.

518. Advanced Farm Animal Nutrition. (5-0) Cr. 5. F. *Prereq: 319.* Nutritional requirements for reproduction, production, lactation and growth; feeding programs, and current research for farm animals.

533. Physiology and Endocrinology of Animal Reproduction. (V P P 533) (3-0). Cr. 3. S. *Prereq: General physiology course.* Development of structure and function of the reproductive system. Physiologic and endocrine aspects including puberty, gametogenesis, estrous cycle, pregnancy, parturtion, interaction of environment, thyroid and adrenal function, and nutrition with these processes.

550. Population Genetics. (Gen 550) (3-0) Cr. 3. S. *Prereq: Stat 401.* Statistical methodology in the study of population genetics. Concepts of a population. Study of qualitative and quantitative population genetics including equilibrium and dynamic populations.

570. Advanced Meat Science and Applied Muscle Biology. (2-2) Cr. 3. S. *Prereq: 370.* Chemistry and microscopic structure of muscle tissue. Post-mortem changes in muscle and their relationship to muscle as a food. Palatability and processing characteristics and factors affecting these characteristics. Laboratory practice and experimentation.

590. Special Topics. Cr. 1 to 3. F.S.SS. *Prereq: Permission of instructor.* Special topics in the animal sciences, offered on demand and often conducted by guest professors.

A. Animal Breeding
B. Animal Nutrition
C. Meat Animal Production
D. Dairy Production
E. Meat Science
F. Physiology of Reproduction
G. Muscle Biology
H. Poultry Nutrition
I. Poultry Products
J. Experimental Surgery
K. Professional Topics

Courses for Graduate Students, major or minor.

603. Seminar in Animal Nutrition. (1-0) Cr. R. F.S. *Prereq: Permission of instructor.* Discussion of current literature; preparation and submission of abstracts.

610. Ruminology. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: Permission of instructor.* Anatomy and physiology of the ruminant digestive tract. Description and metabolism of ruminal and intestinal microbes. Utilization of end-products absorbed from tract. Abnormal rumen function.

618. Advanced Nutrition — Minerals and Vitamins. (3-0) Cr. 3. F. *Prereq: B B 405.* Role of vitamins and minerals in mammalian intermediary metabolism. Integration of cellular biochemistry and physiology of vitamins and minerals.

619. Advanced Nutrition — Protein. (2-0) Cr. 2. S. *Prereq: B B 405.* Digestion, absorption, and intermediary metabolism of amino acids and protein. Integration of cellular biochemistry and physiology of mammalian protein metabolism.

620. Advanced Nutrition — Energy. (2-0) Cr. 2. S. *Prereq: B B 405.* Energy constituents of feedstuffs and energy needs of animals as related to cellular biochemistry and physiology. Interpretations of classical and current research.

633. Seminar in Animal Reproduction. (1-0) Cr. 1. F. *Prereq: Permission of instructor.* Discussion of current literature and preparation of reports on selected topics concerning physiology of reproduction.

651. Methodology in Animal Breeding. (3-0) Cr. 3. F. *Prereq: 550, Stat 402.* Techniques and statistical tools useful in animal breeding theory and application. Correction for environmental effects, estimation and interpretation of components of variance, heritabilities, genetic correlations, and their standard errors. Kinds of selection index theory.

652. Population Dynamics in Animal Breeding. (2-2) Cr. 3. S. *Prereq: 651.* Population size, inbreeding, selection intensity, and selection schemes as they affect rate of genetic change in farm animals. Conditions for optimum change, genetic limits, and equilibria.

653. Applied Poultry and Swine Breeding. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 651.* Industrial application of breeding systems, selection methods, inbreeding, and hybridization.

654. Applied Beef and Dairy Cattle Breeding. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 651.* Industrial application of breeding systems, sire selection and evaluation, and crossbreeding.

670. Molecular Biology of Muscle. (B B 670) (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: B B 405, 420, or 502.* Microstructure and chemical composition of muscle tissue. Chemistry, function, and turnover of muscle and connective tissue protein. Molecular aspects of muscle contraction.

680. Modern Views of Nutrition. (F N 680) (2-0) Cr. R. S. Current concepts in nutrition and related fields. Required for all graduate students in nutrition.

684. Seminar in Meat Science. (1-0) Cr. 1. S. *Prereq: Permission of instructor.* Discussion and evaluation of current topics in research publications in meat science.

685. Seminar in Muscle Biology. (1-0) Cr. 1. S. *Prereq: Permission of instructor.* Reports and discussion of recent literature and current investigations.

699. Research.
A. Animal Breeding
B. Animal Nutrition
C. Meat Animal Production
D. Dairy Production
E. Meat Science
F. Physiology of Reproduction
G. Muscle Biology
H. Poultry Nutrition
I. Poultry Products

Anthropology

For description of courses, see *Sociology and Anthropology*.

Architecture

Chair of Department

The Graduate Faculty

Members: Greenfield, Shao, Woods

Associate Members: Block, Findlay, Hawk, Heemstra, Kainlauri, Kitzman, Kocimski (Emeritus), Lorr, Masterson, McKeown, Mukerjea, Osterberg, Robinson, Shank, Slater, Stone

The department offers several graduate programs leading to the professional degree Master of Architecture with major in architecture. Minor work is offered to students taking major work in other departments.

The programs leading to the Master of Architecture degree are designed to educate professional architects to work effectively within contemporary constraints, to comprehend continuing changes within our society, and to formulate concepts for a better human environment.

The programs of study are:

Program 1: A 30-graduate-credit program for those holding the degree Bachelor of Architecture.

Program 2: A 60-credit program for those holding the degrees B.A. or B.S. in architecture or environmental design.

Program 3: A program of more than 60 credits tailored to the experience, training, and education of students with other baccalaureate degrees.

In programs 2 and 3, a minimum of 40 credits must be graduate credits.

It is possible to arrange a program of study for the Master of Architecture degree on a non-thesis basis.

Admission to the graduate programs will be based on the qualifications of the applicants and on available resources in the department.

The Master of Architecture degree program following the degree Bachelor of Architecture shall include:

Cr.	
2	Arch 501
10	Thesis or terminal studio*
18	Electives
30	Total credits

The Master of Architecture degree program following the degree B.A. or B.S. in architecture or environmental design shall include:

Cr.	
2	Arch 501
10	Arch 605, 606
3	History, theory and criticism options**
6	Building sciences options***
10	Thesis or terminal studio*
12	Concentration****
17	Electives****
60	Total credits

All graduate programs require the guidance of a graduate program of study committee.

An optional one-semester foreign study program may be offered depending on available resources in the department.

The department also participates in the interdepartmental programs in Energy Systems Engineering and Housing. (See *Index*)

*Not more than 5 additional credits may be drawn from elective credits as needed for thesis work to be approved by major professor and program of study committee. The terminal studio is a faculty approved creative component which meets the Graduate College requirements.

**Student's choice from among a faculty approved list of courses.

***For the first professional degree, B. Arch. or M. Arch, 10 credits in structures and 12 credits in architectural technologies are required. These 22 credits will include the 16 credits taken in structures and architectural technologies under Building Sciences in the B.A. in Architecture program. Student's choice from among a faculty approved list of courses.

****To be approved by major professor and program of study committee.

Courses for Graduate Students, minor only

421, 422, 423, 424, 425. History, Theory, and Criticism of Architecture. (3-0) Cr. 3 each. 421: Alt S.; 422: F.; 423: S.; 424: F.; 425: F.S. *Prereq: for each: 321.* An integrated study of the history, theory, and principles of architecture and urban design considering relationships to the culture, visual arts, site, and surroundings. Field trips. Fee. 421: Ancient. 422: Medieval. 423: Renaissance to mid-eighteenth century. 424: Nineteenth century. 425: Twentieth century.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501. Seminar. (2-0) Cr. 2. F.S. Professional philosophy. Investigation of traditional and new roles in architectural practice.

502. Seminar. (1-0 to 3-0) Cr. 1 to 3 each time taken. F.S. Investigation of the changing relationships between professional practice and the needs of society.

507. Urban Housing Studio. (0-18) Cr. 6. F.S. *Prereq: Admission to the B. Arch or graduate program.* Design of moderate to high density housing in urban environments.

508. Urban Design Studio. (0-18) Cr. 6. F.S. *Prereq: Admission to the B. Arch. or graduate program.* Urban design processes applied to contemporary urban settings.

509. Environment-Behavior Studio. (0-18) Cr. 6. F.S. *Prereq: Admission to the B. Arch. or graduate program.* Solving physical environment problems through the analysis of human behavior.

511. Architectural Luminous Environment. (3-0). Cr. 3. F. *Prereq: 311, 312.* Natural and artificial lighting. Visual stimuli, comfort, discomfort, perception, and active and passive systems of control. Field trip. Fee.

512. Architectural Thermal Environment. (3-0). Cr. 3. F.S. *Prereq: 311, 312.* An integration of the concepts of thermal stimuli, comfort, discomfort, active and passive systems of control. Field trip. Fee.

513. Architectural Acoustic Environment. (3-0). Cr. 3. S. *Prereq: 311, 312.* An integration of the concepts of acoustic stimuli, comfort, discomfort, active and passive systems of control. Field trip. Fee.

514. Sanitary Systems. (3-0). Cr. 3. F. *Prereq: 311, 312.* An integrated study of the principles of drainage, water supply and treatment. Systems pertaining to sites and buildings. Field trip. Fee.

515. Concepts in Building Fire Safety. (3-0) Cr. 3. S. *Prereq: 306, 311, 312 or M E 440 or M E 442.* Theory of fire behavior, site planning for fire apparatus, materials, construction, detection, suppression, escape and refuge, codes as they relate to architecture. Field trip. Fee.

516. Construction Methods. (3-0) Cr. 3. F. *Prereq: 311, 312, or M E 440 or M E 442.* Advanced studies of construction methods and procedures. Field trip. Fee.

517. Advanced Studies in Building Systems. (3-0) Cr. 3. S. *Prereq: 512 or M E 440 or M E 442.* Integration and development of technical building systems. Field trip. Fee.

521. Topical Studies in History, Theory, and Criticism of Architecture. (3-0) Cr. 3 each time taken. F.S. *Prereq: Permission of instructor.* Field trips. Fee.
A. Pre-Modern
B. Modern
C. American
D. Oriental and other non European
E. Architects
F. Historic Preservation
G. Technical, Structural, and Programmatic
I. Urban Design

532. Advanced Two-Dimensional Studio. (0-6) Cr. 2 each time taken. F.S. *Prereq: 332.* Advanced studies in visual design. Emphasis on materials, techniques, scale, and color/shape relationships. Potential of expressive, decorative, and optical effects for independent and architecturally integrated projects. No more than 8 credits may be applied toward a degree in architecture for the sum of credits earned in 332 and 532.

533. Advanced Three-Dimensional Studio. (0-6) Cr. 2 each time taken. F.S. *Prereq: 204.* Advanced investigation of sculptural expression with emphasis on individual interest. No more than 8 credits may be applied toward a degree in architecture for the sum of credits earned in 204 and 533.

541. Human Thermal Environments. (M E 541). See *Mechanical Engineering*.

543. Office Practice. (3-0). Cr. 3. S. *Prereq: 311, 312, 306 or I Ad 315.* Contracts, documents, specifications, working drawings, office procedures, and administration. Field trip. Fee.

544. Advanced Topics in Architectural Technologies. (3-0). Cr. 3. each time taken. F.S. Prereq: 311, 312. Field trip. Fee.
A. Materials
B. Structural Systems
C. Conveying Systems

D. Industrialized Building Systems and Components
E. Alternative Energy Systems
F. Appropriate Technology

556. Case Studies in Architecture. (3-0) Cr. 3. S. *Prereq: 3 semesters of design.* In-depth investigations of specific, real-world problems of architecture or building utilizing the case method approach; includes interviewing design professionals, clients, and users and analyzing data found in construction documents and reports. Extensive documented final report.

566. Housing the Elderly, Disabled, and Low-Income. (3-0) Cr. 3. F. *Prereq: Admission to the B. Arch. or graduate program.* Social, psychological, and economic parameters of residential architecture for independent and institutionalized persons.

572. Advanced Architectural Programming. (3-0) Cr. 3. F. *Prereq: 372.* Determination of space, site, and cost factors for design. Procedures methods and techniques.

573. Post-Occupancy Evaluation. (3-0) Cr. 3. S. *Prereq: Admission to the B. Arch. or graduate program.* Methods of evaluating the physical, social, and psychological performance of buildings following construction and occupancy, with emphasis on behavioral response to the environment and its role in the design process.

574. Real Estate Investment Aspects of Architecture. (3-0) Cr. 3. S. *Prereq: 405 or 406.* Principles of real estate investment and an analysis of their influence on architectural design. Field trip. Fee.

576. Research Methods for Environmental Designers. (3-0) Cr. 3. F. *Prereq: Admission to the B. Arch. or graduate program.* Examination of qualitative and quantitative methods of inquiry with specific application to environmental design.

577. Social Impact of the Physical Environment. (3-1) Cr. 4. S. *Prereq: Admission to the B. Arch. or graduate program.* Interdisciplinary review and analysis of social scientific research applied to architectural design.

585. Contemporary Urban Design Theory. (3-0) Cr. 3. F.S. *Prereq: Admission to the B. Arch. program or graduate program.* Current urban design theory and its application to urban problems.

590. Special Topics. Cr. 1 to 5 each time taken. F.S.SS. *Prereq: Written approval of instructor and department head.* Projects of special interest to the student.

Courses for Graduate Students, major or minor

605, 606. Architectural Design. (0-15) Cr. 5 each. 605: F. 606: S. *Prereq: Admission to M. Arch. program.* Architectural design problems of increased complexity.

607. Advanced Architectural Design. (0-15) Cr. 5. F.S. *Prereq: Professional degree in architecture.* Architectural design problems of increasing complexity.

608. Individual Design Projects. (0-9 to 0-36) Cr. 3 to 12 each time taken. F.S. *Prereq: Approval of major professor.*

699. Research. Cr. Var. F.S.SS.

Art and Design

Jon H. Sontag, Chair of Department

The Graduate Faculty

Members: Evans, Heggen, Miller, Sontag, Watson (Emeritus)

Associate Members: Adams (Emeritus), Allen, Fowler, Held, Meixner, Pickett, Townsend

The department offers work for the degree Master of Arts in art and design and minor work to students taking major work in other departments. Within art and design, the graduate student may specialize in advertising design, art education, craft design, and interior design.

A student in the graduate program may select either a thesis or nonthesis option under the department Master of Arts degree program. The thesis option requires a minimum of 30 graduate credit hours and the completion of a thesis. The nonthesis option requires a minimum of 34 credit hours and the development of a research project, or an exhibition. In either option a minimum of 6 credit hours of related course work is required outside of the department. Specific information about the requirements for either of the degree options is available from the departmental office.

The department also cooperates in the interdepartmental minor program of Housing (see *Index*).

433. Advanced Painting. (1-5) Cr. 3 each time taken, maximum of 9. F.S. *Prereq: 333.* Figurative and/or non-figurative painting with extended work in media and composition. Fee.

450. Advanced Drawing. (1-5) Cr. 3 each time taken, maximum of 9. F.S. *Prereq: 235.* Figurative and/or non-figurative drawing with extended work in media, composition, and theory. Fee.

469. Commercial Interior Design II. (2-6) Cr. 4. F.S. *Prereq: 369, credit or classification in 463.* Research and design problems relating to specialized institutional environments and complex multi-unit planning. Professional ethics, general business procedures, and written specifications. Fee.

471. Graphic Illustration. (1-5) Cr. 3. F.S. *Prereq: 370.* Exercises with varied techniques in both black and white and color. Fee.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

550. Advanced Drawing. (1-5) Cr. 3 each time taken, maximum of 9. F.S. *Prereq: 12 credits of undergraduate drawing.* Figurative and/or non-figurative drawing with extended work in media, composition, and theory. Fee.

590. Special Topics. Cr. arr. F.S.SS. *Prereq: Bachelor's degree in art and/or design, or evidence of satisfactory equivalency in specialized area.*
A. Drawing
B. Painting
C. Art Education
D. Art History
E. Interior Design
F. Graphic Design
I. Clay
J. Wood
K. Metal
L. Fiber
M. Printmaking
N. Design

Courses for Graduate Students, major or minor

605. Seminar. Cr. 2. F.S.

699. Research. Cr. var. F.S.SS.

Astronomy and Astrophysics

For description of courses, see *Physics*.

Bacteriology

See *Microbiology*.

Biochemistry and Biophysics

James Allen Olson, Chair of Department

The Graduate Faculty

Members: Applequist, Atherly, Beitz, Bremner, Cox, Foss, French, Fromm, Graves, Hammond, Horowitz, Metzler, Olson, Outka, Rebers, Robson, Robyt, Rougvie, Stone, Stromer, Thomas, Tipton, Warner, Young

Associate Member: White

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in biochemistry; biophysics; and molecular, cellular, and developmental biology; and minor work to students taking major work in other departments.

The department also participates in the interdepartmental programs in Immunobiology, and Molecular, Cellular, and Developmental Biology. (See Index.)

Prerequisite to graduate work is completion of sufficient undergraduate work in chemistry, mathematics, physics, and biology.

All graduate students are required by the department to teach as part of their training for an advanced degree.

Candidates for the degree doctor of philosophy must demonstrate a reading knowledge of one foreign language, preferably French, German, or Russian, either by passing (50th percentile or better) the Educational Testing Service examination or obtaining a grade of C or better in a one-year college course in a foreign language. A foreign student whose native language is Chinese, French, German, Italian, Japanese, Russian, or Spanish may be excused from the foreign language requirement.

Courses for Graduate Students, minor only

†*404,†*405. Biochemistry. (3-0) Cr. 3 each. Yr. *Prereq: 404: Chem 332; 405: 404.* A fundamental rigorous treatment for graduate and advanced undergraduate students in agricultural, biological, and nutritional sciences. 404: Chemistry of amino acids, proteins, carbohydrates, lipids, vitamins, and nucleotides; enzymology; metabolism of carbohydrates and lipids. 405: Metabolism of amino acids and nucleotides; biosynthesis of membranes, DNA, RNA, and proteins; genetic code; metabolic regulation; comparative biochemistry, and selected topics.

411. General Biochemical Research Techniques. (1-6) Cr. 3. F. *Prereq: 201 or 404 or 501; Chem 210 or 211.* Introduction to techniques for studying biochemistry, including: paper, gas, and column chromatography; enzyme isolation and kinetics; use of radioisotope tracers.

***420. Physiological Chemistry.** (4-0) Cr. 4. F. *Prereq: 301 and Chem 332.* Structure and function of proteins; enzymology; biological oxidation; chemistry and metabolism of carbohydrates, lipids, amino acids and nucleic acids; protein synthesis and the genetic code; relationship of biochemistry to selected animal diseases. Biochemistry of higher animals will be emphasized. Not acceptable for credit toward a major in biochemistry or biophysics.

451. Introduction to Physical Biochemistry. (2-0) Cr. 2. S. *Prereq: Chem 331; Phys 112 or 222; a previous course in calculus is helpful but not required.* Selected topics in physical chemistry in the context of applications to problems in biology, biochemistry and food sciences. Not acceptable for credit toward a major in biochemistry or biophysics.

461. Introduction to Biophysics. (2-0) Cr. 2. F. *Prereq: 451 or Chem 321 or 324 or Phys 304.* Biological phenomena viewed as problems in physics. Survey of selected topics such as bioenergetics, muscle contraction, nerve conduction, vision, and macromolecular behavior.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501, 502. General Biochemistry. (4-0) Cr. 4 each. Yr. *Prereq: 501: Chem 210 or 211; 332; and 322 or 325; 502: 501.* Chemical composition of living matter and the chemistry of life processes. 501: Chemical characterization of amino acids, proteins, carbohydrates, lipids, and nucleotides; membranes; enzymology and co-enzymes; metabolism of carbohydrates and lipids; biological oxidations. 502: Metabolism of amino acids and nucleotides; biosynthesis of DNA, RNA, and proteins; genetic code; hormones and metabolic regulation; molecular immunology; muscle biochemistry. For graduate students in biochemistry and biophysics, advanced undergraduates in biochemistry or chemistry, and qualified students desiring a rigorous course.

511. Topics in Experimental Biochemistry. Cr. var. 1-3. S. *Prereq: 404 or 501 and Chem 210 or 211.* Use of selected techniques to examine biological macromolecules; physical-chemical characterization of proteins and nucleic acids; enzymology; molecular biology. Taught as individual one-credit modules.

521. Radiobiochemistry. (2-6) Cr. 2. S. 8 weeks. *Prereq: 404 or 501 and Chem 210 or 211.* A laboratory course in biochemical uses of radioisotopes. Basic counting techniques, liquid scintillation counting, isotope dilution techniques, radio-autography, radioimmunoassay, and elucidation of reaction mechanisms using labeled compounds.

†526. Cell Biology of Selected Eukaryotic Cell Systems. (2-0) Cr. 2. F. Outka. *Prereq: 405 or 502, Zool 428 or 325, or Bot 444.* Primitive motile systems and their assembly: microtubules and filaments, cilia, flagella, pseudopodia, cell membrane elaborations, extracellular matrices, cell walls. Cytoplasmic inheritance: centrioles, basal bodies, mitochondria, plastids. Somatic cell hybridization: mouse-human hybrids, plant cell hybrids, totipotency, C-4 photosynthesis, nitrogen fixation.

551. Molecular Biophysics. (3-0) Cr. 3. F. *Prereq: Math 166; permission of instructors.* Foss, Rougvie. An examination of physical methods for the study of the molecular structure and organization of biological materials, with emphasis on applications. Spectroscopy, hydrodynamic methods, and X-ray diffraction.

574. Microscopy. (2-0) Cr. 2. S. *Prereq: Permission of instructor.* Outka. Principles, methods, and applications of light and electron microscopy. Light optics including phase contrast, fluorescence, and polarization. High resolution electron optics. Specimen preparation. Photography.

575. Laboratory in Microscopy. (0-6) Cr. 2. S. *Prereq: Credit or classification in 574.* Outka. Practical experience in microscopy. Designed to be taken concurrently with 574.

581. Seminar. (1-0) Cr. 1. F. *Prereq: Permission of instructor.* Short talks and discussion by students on assigned topics. For entering graduate students and qualified seniors.

590. Special Topics. F.S.SS. Cr. arr.

591. Optical Instrumentation Laboratory. Cr. 1. SS. *Prereq: Permission of instructor.* Foss. Training in the operation of spectrophotometers, spectrophotofluorimeter, and dichrograph. A concentrated one week course for students planning research use of this instrumentation.

592. Analytical Ultracentrifugation Laboratory. Cr. 1. SS. *Prereq: Permission of instructor.* Rougvie. Training in the operation of the analytical ultracentrifuge. A concentrated one week course for students planning research use of this instrument.

Courses for Graduate Students, major or minor

615. Molecular Immunology. (Micro 615) (2-0) Cr. 2. F. Warner. *Prereq: 405 or 502.* Contemporary topics in immunochemistry, immunobiology, and immunogenetics.

†622. Carbohydrate Chemistry. (2-0) Cr. 2. Alt. SS., offered 1982. French, Robyt. *Prereq: 404 or 501.* Chemistry and biochemistry of simple and complex carbohydrates.

630. Lipids. (2-0) Cr. 2. Alt. SS., offered 1983. Tipton. *Prereq: 405 or 502.* The metabolism of complex lipids and the role of lipids in the structure and function of biological membranes.

632. Kinetics of Enzyme Action. (2-0) Cr. 2. Alt. F., offered 1982. Fromm. *Prereq: 501.* Topics covered will include: enzyme-substrate interaction, inhibition, functional groups involved in catalysis, isotope exchange, allostery, integrated rate equations and pre-steady state kinetics.

642. Mechanism of Action of Enzymes and Coenzymes. (2-0) Cr. 2. Alt. F., offered 1981. Metzler. *Prereq: 404, 420, or 501.* Chemical mechanisms of enzymatic catalysis; chemistry of vitamins, coenzymes, prosthetic groups, and metal-containing centers of enzymes.

645. Biochemistry of Metabolic Regulation. (3-0) Cr. 3. Alt. F., offered 1981. Beitz, Thomas. *Prereq: Credit or classification in 420, 405, or 502.* Advanced topics in regulation of metabolism with emphasis on important regulatory molecules, and mechanisms of enzyme regulation. The second half of the course will deal extensively with molecular mechanisms of selected hormone action.

650. Biochemical Thermodynamics. (2-0) Cr. 2. Alt. S., offered 1982. Applequist. *Prereq: Chem 321 or 324.* Biochemical phenomena such as metabolism, coupled reactions, denaturation of macromolecules, cooperativity, and membrane phenomena studied in the framework of thermodynamic principles.

652. Protein Chemistry. (2-0) Cr. 2. Alt. S., offered 1983. Graves, Robyt, *Prereq: 404 or 501.* Chemical reactions and physical changes of proteins as a means of determining their structures and biological functions.

†670. Molecular Biology of Muscle. (An S 670) (3-0) Cr. 3. Alt. F., offered 1982. Robson, Stromer. *Prereq: 405, 420, or 502.* Microstructure and chemical composition of muscle tissue. Chemistry, function, and turnover of muscle and connective tissue protein. Molecular aspects of muscle contraction.

675. Nucleic Acids and Gene Regulation. (3-0) Cr. 3. Alt. S., offered 1982. Cox, Horowitz. *Prereq: 405 or 502.* Properties of nucleic acids and nucleoproteins. Relationship of nucleic acid structure to function. Chromatin structure and gene activity. Mechanisms of transcriptional and translational control. Oncogenesis.

681. Advanced Seminar. Cr. 1. F.S. *Prereq: Permission of instructor.* Student presentations.

682. Departmental Seminar. Cr. R. F.S. *Prereq: Permission of instructor.* Staff and visitor presentations.

698. Seminar in Molecular, Cellular, and Developmental Biology. (MCDB 698) See *Molecular, Cellular and Developmental Biology.*

699. Research. *Prereq: Permission of instructor.*

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†Administered by the College of Agriculture. Courses not marked are administered by the College of Sciences and Humanities.

Biology

Warren D. Dolphin, Program Executive Officer
Robert Chapman, Convener, Faculty Committee

Biology as a discipline encompasses a number of departments at Iowa State University. Basic undergraduate and graduate courses are offered in the departments of animal ecology, biochemistry and biophysics, botany, genetics, microbiology, and zoology. In addition, several departments in the colleges of Agriculture, Home Economics, and Veterinary Medicine provide undergraduate and graduate programs in applied and specialized phases of the biological sciences.

Persons interested in graduate study in biology may take the Master of Science or Doctor of Philosophy degree with a major in any of the life science disciplines. Interdepartmental graduate programs in Molecular, Cellular, and Developmental Biology (MCDB), General Graduate Studies, Immunobiology, Biomedical Engineering, and Water Resources are also available.

The master's degree in General Graduate Studies (Biological Sciences) has been established particularly for teachers who wish to broaden and update their formal training in biology.

Course for Graduate Students, minor only

500. History of Biology. (3-0) Cr. 3. S. *Prereq: 12 credits in biological science; history majors 6 credits in biological science.* Biological discovery and its relationship to the cultural setting; influence of biology on social change.

Biomedical Engineering

(Interdepartmental Program)

Richard C. Seagrave, Professor in Charge

The Graduate Faculty

Members: Brockman, Cholvin, Engen, R. T. Greer, Seagrave, Swift, Young

Associate Members: Carithers, Carlson, M. H. Greer.

The Biomedical Engineering (BME) Program is interdisciplinary in scope and is sponsored jointly by the colleges of Engineering and Veterinary Medicine. Biomedical engineers are concerned with the application of engineering concepts and analytical techniques to biological and medical problems. They are interested in developing new concepts and instrumentation for measurements of living systems. In addition, they seek to understand those phenomena of living systems which have functional capabilities desirable in the design of physical systems. Following completion of biomedical engineering training, they engage in research careers in the various fields of biomedicine and engineering, and in the environmental sciences. They may work on multidisciplinary teams in industrial, governmental, or academic research institutes. Individuals with this training can correlate and adapt engineering principles to the problems of medicine and biology, by utilizing engineering knowledge to increase understanding of the functions of biological systems, and by developing new quantitative methods for scientific investigation, and for diagnosis and therapy.

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in biomedical engineering, and minor work for students taking major work in other areas. Prerequisite to major and minor work in the interdepartmental program of biomedical engineering is an undergraduate degree in one of the fields of engineering, life sciences, physical sciences, or a professional degree in one of the fields of medicine.

Depending upon the individual's background, the BME major will usually elect minor work in one of the following curricula: biochemistry and biophysics, chemical engineering, computer science, electrical engineering, engineering mechanics, mathematics, mechanical engineering, psychology, veterinary anatomy, veterinary clinical sciences, veterinary pathology, veterinary physiology, or zoology. All students are encouraged to obtain previous background knowledge of organic chemistry, calculus, beginning differential equations, and physics.

The program of formal courses taken by students is oriented toward developing proficiency in research in the interdisciplinary field or in utilizing biomedical principles in clinical situations. Selected background and advanced courses from related disciplines are taken in conjunction with appropriate biomedical engineering courses.

The program of formal courses varies, depending upon the background and interests of the student, and is determined in consultation with the student's committee.

Courses Primarily for Graduate Students, major or minor

520. Biomechanics. (E M 520) (3-0) Cr. 3. S. *Prereq: Phys 111 or 221; Math 265.* For students with interests in the life sciences who wish to obtain background in applied mechanics. Topics include equilibrium, vibratory motion, stress and deformation, material properties, flow of fluids, dimensional analysis and modeling of biological systems. Illustrative examples taken from biology and medicine.

525. Anatomy and Physiology for Biomedical Engineers. (2-1) Cr. 3. F. *Prereq: Phys 221.* Microscopic and gross anatomy with emphasis on functional relationships and engineering design.

530. Biothermodynamics and Transport Phenomena. (3-0) Cr. 3. S. *Prereq: Math 176 or 266, Phys 222.* The principles of thermodynamics and transport phenomena applied to the study of physiology and the design and operation of artificial organs and life support systems.

551, 552. Advanced Vertebrate Physiology. (V P P 551, 552, Zool 551, 552). See Zoology.

555. Biomedical Fluid Mechanics. (E M 555) (3-0) Cr. 3. S. *Prereq: 520.* Application of principles and concepts of fluid mechanics to problems in biology and medicine. Hemodynamic characteristics of the circulation, rheology of blood, flow in the microcirculation, flow in the large arteries, and the respiratory system.

560. Clinical Engineering. (3-0) Cr. 3. S. *Prereq: E E 441.* Principles of electronic monitoring in health care facilities; physiologic effects of electric current, electric shock hazards, power distribution systems consideration. Application of solid-state devices for analog signal measurement and processing, digital signal processing.

565. Electrophysiology. (2-0) Cr. 2. S. *Prereq: 551, Math 176, Phys 222.* Electrical events in living systems. Mathematical and electrical models for resting and action potentials in nerves and for transmission between cells.

570. Biomedical Instrumentation. (3-0) Cr. 3. S. *Prereq: E E 441.* Characteristics of biological signals, transducers, error and artifact suppression, biological data acquisition and processing systems.

575. Simulation of Biological Systems. (3-0) Cr. 3. F. *Prereq: 525, 530.* Development of mathematical models for living systems, including control systems, population dynamics, cardiovascular and respiratory systems, and anesthesia delivery systems.

580. Biomaterials. (E M 580, M S E 580) (3-0) Cr. 3. S. *Prereq: M S E 270, permission of instructor.* Presentation of the basic chemical and physical properties of biomaterials as they are related to their manipulation by the engineer for incorporation into living systems. Role of microstructure properties in the choice of biomaterials and design of artificial organs, implants, and prostheses.

585. Information Processing in Living Systems. (3-0) Cr. 3. S. *Prereq: E E 441.* Nervous and neuron network models, information processing in living systems, artificial intelligence, pattern recognition.

590. Special Topics. Cr. 1 to 5 as arranged. Investigation of problems of special interest in biomedical engineering.

595. Biomedical Data Processing. (2-0) Cr. 2. F. *Prereq: E E 441.* Digital data acquisition systems used in biomedical research, hardware, data reduction algorithms, digital filters.

Courses for Graduate Students, major or minor

610. Cardiovascular Transport and Control. (2-0) Cr. 2. S. *Prereq: 525, 530.* Quantitative biophysics underlying the transport of material and energy in the cardiovascular system with special emphasis on control.

615. Experimental Surgery. (1-3) Cr. 2. SS. *Prereq: 525.* Advanced surgical procedures for quantitative studies in biomedical engineering.

690. Advanced Topics. Cr. 1 to 5 as arranged.
A. Instrumentation
B. Simulation
C. Transport Phenomena
D. Biomaterials
E. Information Processing

699. Research.

Botany

Ronald C. Coolbaugh, Chair of Department

The Graduate Faculty

Members: Anderson, Bowen, Coolbaugh, Davis, Dodd, Farrar, Glenn-Lewin, Horner, Isely, LaMotte, Lersten, Nevins, Outka, Pohl, Smith, Stewart, Swenson, Tiffany, van der Valk

Associate Members: Chapman, Pearlmutter

The department offers work for the degrees Master of Science and Doctor of Philosophy with a major in botany, and minor work for students majoring in other departments. Within the botany major one of the following areas of specialization may be designated: aquatic plant biology, cytology, ecology, economic botany, morphology, mycology, physiology, or taxonomy.

The department also participates in the interdepartmental programs of Water Resources; and Molecular, Cellular, and Developmental Biology. (See Index.)

Prospective graduate students need a sound background in the physical, biological, and mathematical sciences, in English, and a reading proficiency in at least one foreign language. The department requires submission of Graduate Record Examination aptitude test scores. For the Ph.D. degree, reading proficiency in one foreign language is required. This may be demonstrated by two years of course work, an ETS language examination, or a departmentally administered examination.

Courses for Graduate Students, minor only

***320. Plant Physiology.** (3-3) Cr. 4. S. *Prereq: 207; Chem 331 or B B 301.* Nevins. Application of physical and biological principles to the understanding of plant processes involved in assimilation, metabolism, and regulation of growth and development.

403. Introductory Microtechnique. (0-3) Cr. 1. F.SS. *Prereq: Classification in 404.* Lersten. Includes paraffin method, freehand sectioning, clearing technique, macerations.

404. Plant Anatomy. (2-2) Cr. 3. F.SS. *Prereq: 207; 306 recommended.* Lersten. Characteristics of cell and tissue types in vascular plants. Anatomy of developing and mature stems, roots, and leaves.

405. Natural History of Plants. (3-6) Cr. 5. S. *Prereq: 207.* Farrar, Lersten, Pearlmutter. Evolutionary survey of algae, bryophytes, pteridophytes, gymnosperms, and angiosperms, including special aspects of ecology and physiology of non-flowering plants.

406. Principles of Mycology. (2-3) Cr. 3. F. *Prereq: 10 credits in biological sciences.* Tiffany. Morphology, taxonomy and ecology of fungi; their relation to agriculture and industry.

424. Nature and Management of Vegetation. (2-3) Cr. 3. F.SS. *Prereq: A course in plant identification; Biol 312.* Physical and biological factors controlling the composition and structure of natural plant communities. Techniques for sampling, classifying, and managing prairie, forest, and wetland vegetation. Collection and identification of common plant species. Saturday field trips.

444. The Cell. (3-0) Cr. 3. F. *Prereq: 10 credits in biology including genetics; credit or classification in B B 301 recommended.* The anatomy and physiology of cytoplasm. The nucleus and its role in development and reproduction. See 544 for accompanying laboratory.

484. Plant Ecology. (3-0) Cr. 3. S. *Prereq: Biol 312.* Glenn-Lewin. Principles of plant population, community, and ecosystem ecology.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Field Biology of Freshwater Algae. (2-3) Cr. 3. F. (SS Lakeside Lab). *Prereq: 10 credits in biological sciences.* Dodd. Introduction to major groups of algae and their roles in freshwater habitats. Environmental factors affecting growth and reproduction. Fee for field trips. May be taken in summer at Iowa Lakeside Laboratory with written permission of instructor.

501. Marine Algae. (2-0) Cr. 1. Alt. S., 8 weeks, offered 1982. *Prereq: 10 credits in biological sciences.* Pearlmutter. Morphology, ecology, and distribution of marine algae. Emphasis on the macroalgae.

502. Cytology and Physiology of Algae. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 500, Chem 331 or B B 405.* Pearlmutter. Cell structure and function. Factors affecting the metabolism, morphogenesis, and reproduction of the algae.

511. Plant Nutrition. (2-0) Cr. 2. F. *Prereq: 320, Phys 111, Chem 331.* Nevins. Mineral nutrition, water relations, and translocation in vascular plants.

512. Plant Growth Regulation. (3-0) Cr. 3. S. *Prereq: 320, Phys 111 or 221, Chem 331.* LaMotte. Vascular plant growth, correlative phenomena in development, and hormones involved in their regulation.

513. Plant Metabolism. (2-0) Cr. 2. S. *Prereq: 320, Phys 111, Chem 331.* Stewart. Photosynthesis, respiration, and other aspects of plant metabolism.

517. Physiological Methods and Techniques. (0-10) Cr. 2. Alt. F., offered 1982. 8 weeks. *Prereq: Credit or classification in 511 or 512 or 513.* Nevins. Research methods and techniques in plant physiology.

529. Fine Structure of Plant Cells. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 310 or 320; 404.* Structure and function of organs, tissues, cells, and cellular components at various levels of evolutionary development.

544. Laboratory in Cytology. (0-3) Cr. 1. F. *Prereq: A course in cell biology or classification in 444.* Optional laboratory to accompany 444. Light microscopic study of the nucleus and chromosomes.

546. Ecology of Aquatic Fungi. (2-6) Cr. 2. Alt. S., offered 1982. 8 weeks. *Prereq: 406.* Aquatic fungi and their roles in fresh-water habitats. Procedures for collection, culture, and identification.

551. Lichens and Bryophytes. (2-4) Cr. 2. Alt. F., offered 1982. 8 weeks. *Prereq: 10 credits in biological science.* Tiffany, Lersten. Morphology, classification, and natural history; collection and identification of specimens. Fee for one weekend field trip.

552. Pteridology. (1-3) Cr. 2. Alt. SS., offered 1982. *Prereq: 10 credits in biological sciences.* Farrar. Morphology, taxonomy, and ecology of the lower vascular plants, with emphasis on ferns. Fee for field trips.

553. Sexual Reproduction in Flowering Plants. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 10 credits in biological sciences, including Bot 306.* Lersten. Development of reproductive structures; pollination, fertilization, embryo and seed development.

558. Paleobotany. (2-4) Cr. 2. Alt. F., offered 1982. 8 weeks. *Prereq: 10 credits in biological sciences.* Farrar. Introduction to morphology, identification, and phylogeny of fossil plants from Pre-Cambrian to present.

559L. Field Biology of Bryophytes and Pteridophytes. (See list of courses offered at *Iowa Lakeside Laboratory.)*

564. Wetland Ecology. (2-3) Cr. 3. F. *Prereq: 10 credits in biological sciences.* van der Valk. Role of vascular plant communities in lakes, rivers, marshes, and

swamps. Collection and identification of aquatic vascular plants. Techniques for sampling and managing wetland vegetation. Fees for weekend field trips.

575. Field Mycology. (2-6) Cr. 4 each time taken. SS., offered 1983 (SS II, 1982, Lakeside Lab). *Prereq: 5 credits in botany.* Tiffany. Collection and identification of fungi and relation of their occurrence to environmental factors. Preparation and utilization of mycological exsiccati. Fee for field trips. May be taken at Iowa Lakeside Laboratory with written permission of instructor.

584. Plant Communities and Ecosystems. (3-0) Cr. 3. S. *Prereq: 424 or 484.* Historical survey of approaches to the study of plant communities and ecosystems.

585. Advanced Field Ecology. (0-6) Cr. 2 each time taken. F.S. *Prereq: Graduate classification.* Weekend and extended field trips to various vegetation types with emphasis on field problems. Report required. Fee charged.

588. Plant Population Biology. (2-3) Cr. 3. Alt. S., offered 1983. *Prereq: 10 credits in biological sciences.* Chapman. Theoretical and experimental approaches including models, natural selection, gene flow, genetic structure, speciation, hybridization, demography, population growth, and competition.

590. Special Topics. Cr. 1 to 3 each time taken. *Prereq: 10 credits in botany, permission of instructor.*
A. Morphology
B. Physiology
D. Mycology
E. Taxonomy
F. Plant Ecology
G. Eonomic Botany
J. Cytology
K. Aquatic Plant Biology

595. Agrostology. (2-3) Cr. 3. F. *Prereq: 306.* Structure, classification, phylogeny, and economic aspects of grasses; identification of grasses.

Courses for Graduate Students, major or minor

624. Physiology of Fungi. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 406, Chem 331 or B B 301.* Nutrition, metabolism, growth, reproduction, and morphogenesis of fungi.

641, 642. General Mycology. (2-6) Cr. 4 each. Yr. *Prereq: PP SW 407, or 416, or 417.* Tiffany. Taxonomy, morphology, and phylogeny of slime molds and fungi (phycomycetes, ascomycetes, basidiomycetes, and fungi imperfecti).

679. Light and Scanning Electron Microscopy. (2-12) Cr. 6. F. *Prereq: Chem 331, permission of instructor.* Horner. Current theories and methods encompassing light and scanning electron microscopy of biological specimens. Chemical and physical preparations, histochemistry, autoradiography, photomicrography, cytophotometry, and ancillary techniques. Fee.

680. X-ray Microanalysis Using Scanning Electron Microscopy. (1-9) Cr. 4. Alt. S., offered 1983. *Prereq: 679, permission of instructor.* Horner. Qualitative X-ray microanalysis of biological specimens. Bulk and sectioned specimen preparation. Use of transmitted electron detection system. Fee.

681. Transmission Electron Microscopy. (2-12) Cr. 6. Alt. S., offered 1982. *Prereq: Chem 331, Bot 679 and permission of instructor.* Horner. Current theories and methods encompassing transmission electron microscopy of biological specimens. Chemical and physical preparations, negative staining, shadowing, replicas, ultramicrotomy, E M cytochemistry, and EMG analysis. Fee.

684. Plant Ecology Colloquium. (2-0) Cr. 2 each time taken. F.S. *Prereq: Permission of instructor.* Discussion of ecological literature and research: term paper and oral presentation; different topic chosen by instructor each semester.

695. Advanced Plant Taxonomy. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 306, Gen 320.* Isely. Literature and philosophy of biological classification; processes of speciation in higher plants, sources and interpretation of data, research methods, and plant nomenclature.

698. Seminar. Cr. 1 each time taken. Meetings of botany staff and students to discuss recent literature and problems under investigation.
A. Morphology and Taxonomy
B. Plant Physiology
D. For all staff and students in botany
E. Molecular, Cellular, and Developmental Biology (MCDB)
F. Ecology
G. Economic Botany
J. Cytology
K. Aquatic Plant Biology

699. Research.
A. Morphology
B. Physiology
D. Mycology
E. Taxonomy
F. Plant Ecology
G. Economic Botany
J. Cytology
K. Aquatic Plant Biology

*Courses Offered at the Iowa Lakeside Laboratory

301L. (L:101) Field Biology. (4-12) Cr. 2.5. SS. A study of plants in natural environments; includes methods of identification, collection, and preservation as well as basic ecological concepts. Field trips. Must be taken concurrently with Zool 302L.

490. Independent Study. (See preceding section.)

500L. (L:109) Biology of Algae. (8-24) Cr. 5. SS. *Prereq: 10 credits in biological sciences.* Role of algae in freshwater habitats; environmental factors affecting growth and reproduction; introduction to morphology of major groups of algae. Field trips.

559L. (L:119) Biology of Bryophytes and Pteridophytes. (8-24) Cr. 5. Alt. SS., offered 1983. *Prereq: 10 credits in biological science.* Farrar. Collection and identification of mosses, clubmosses, spikemosses, quillworts, horsetails, and ferns. Analysis of microclimates, soils, and community structure, with the goal of explaining and predicting species occurrence.

564L. (L:124) Aquatic Vascular Plants. (8-24) Cr. 5. Alt. SS., offered 1982. *Prereq: 306, Biol 312.* van der Valk. Techniques for surveying aquatic vascular plant communities. Collection and identification of specimens. Environmental factors affecting distribution.

567L. (L:105) Plant Taxonomy. (8-24) Cr. 5. SS. *Prereq: 10 credits in biological science.* Basic principles of classification and evolution of vascular plants. Taxonomic tools, techniques, and the native flora. Group projects.

575L. (L:115) Field Mycology. (8-24) Cr. 5. Alt. SS., offered 1982. *Prereq: 5 credits in botany.* Tiffany. Collection and taxonomy of fungi and relation of their occurrence to environmental factors. Preparation and use of mycological exsiccati. Field trips.

580L. (L:117) Ecology and Systematics of Diatoms. (8-24) Cr. 5. SS. *Prereq: 10 credits in biological science.* Field experience in the study of freshwater diatoms. Environmental factors affecting growth and distribution are stressed. Techniques, collection, and preparation of diatom samples.

590. Special Topics. (See preceding section.)

699. Research. (See preceding section.)

*Written permission of the instructor is prerequisite to all courses offered at the Iowa Lakeside Laboratory. For current information concerning courses, registration, and housing, see the annual Iowa Lakeside Laboratory Bulletin. This bulletin is usually available from participating departments after February 15. Numbers beginning with L indicate numbers used by the University of Iowa.

**Courses Offered at the Gulf Coast Research Laboratory, Ocean Springs, Mississippi

341G. (BO 341) Marine Botany. Cr. 4. *Prereq: 10 credits in biology, including botany.* A survey, based upon local examples of the principal groups of marine algae and marine flowering plants, treating structure, reproduction, distribution, identification, and ecology.

441G. (BO 441) Salt-Marsh Ecology. Cr. 4. *Prereq: A course in general botany, 10 credits in biology.* Emphasis on the botanical aspects of local marshes. Plant identification, composition, structure, distribution, and development of coastal marshes. Biological and physical interrelationships. Primary productivity and relation of marshes to estuaries and associated fauna.

**Written permission of the coordinator of the Gulf Coast Research Laboratory, 201 Bessey Hall, Iowa State University, Ames, Iowa 50011, is prerequisite to all courses offered at the Gulf Coast Laboratory. Numbers beginning with BO are GCRL numbers.

School of Business Administration

Charles B. Handy, Director

The Graduate Faculty

Members: Allen, Handy, Stover

Associate Members: Chacko, Cheney, Elvik, Loudenback, Maydew, McElroy, Millard, Morrow, Teas, Velienga, Voorhees, Zober

The School of Business Administration participates in an interdisciplinary program of Industrial Administrative Sciences (IAS). This program offers a Master of Science degree in industrial administrative sciences as well as minor work for students in other programs.

In addition, the School of Business Administration participates in the interdepartmental graduate program in Transportation Planning. (See Index.)

Courses for Graduate Students, minor only

Accounting (Acct)

480. Cost Accounting. (3-0) Cr. 3. F.S.SS. *Prereq: 285.* Product costing and control as related to job order, process, and standard cost systems. Introduction to cost-volume-profit relationships, operational budgeting, and responsibility accounting.

481. Advanced Cost Accounting. (3-0) Cr. 3. F.S. *Prereq: 480.* Further development of product costing and control procedures. Includes variable costing, capital budgeting, distribution costs, investment and profit centers. Transfer pricing, inventory planning, decision models, mix and yield variances. Field trips.

485. Federal Income Tax. (3-0) Cr. 3. F.S.SS. *Prereq: 381 or 284.* Emphasis on fundamentals of income tax related to an individual taxpayer. Transaction planning to maximize participation in preferential tax opportunities. Limited exposure to characteristics of estate and gift taxes. Introduction to concepts involved in taxation of corporations and partnerships.

486. Advanced Income Tax. (3-0) Cr. 3. F.S. *Prereq: 386, 485.* Extended study for those with a professional interest in income tax. Taxation of corporations, partnerships, estates and trusts as well as more specialized provisions applying to individuals. Research in tax. Preparation of returns including complex transactions.

488. Governmental and Non-profit Institution Accounting. (3-0) Cr. 3 S. *Prereq: 285.* Budgeting, accounting, auditing, and financial reporting principles associated with private and public nonprofit organizations. Includes survey of state, local, municipal, and federal government accounting; college, university, and endowment funds.

Finance (Fin)

451. Real Estate Finance. (3-0) Cr. 3. S. *Prereq: 351.* Decision making in the financing of real estate using basic analytic tools including the applications of various compound interest tables. Principal instruments involved in financing real estate, risk and return analysis, financing techniques, and major institutional sources of funds.

452. Advanced Business Finance. (3-0) Cr. 3. F.S. *Prereq: 350.* Theory used in a firm's investment and financing decisions. Analysis of environment in which financial decisions are made; applications of analytical techniques to problems involved in financial decisions.

454. Principles of Investments. Cr. 3. F.S.SS. *Prereq: 350; Econ 201.* Introduction to various investment media and markets from the viewpoint of the individual investor. Emphasis on financial planning, behavior of security markets, corporate stocks and bonds, individual asset and portfolio selection techniques. Term project required.

455. Security Analysis. Cr. 3. Alt. S., offered 1982. *Prereq: 454.* Analysis of key variables that affect security value. Development of investment strategies. Fundamental and technical analysis. Emphasis on modern portfolio theory based on capital market theory. Term project required.

456. Property and Casualty Insurance. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 357.* Appraisal of property and casualty risks of individual and business organizations. Underwriting of risks.

457. Life Insurance. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 357.* In-depth analysis of health, social, and life insurance. Major emphasis on group policies, retirement plans, business uses of life insurance, and estate planning.

459. Finance Seminar. (3-0) Cr. 3. F.S. *Prereq: 452, 454.* Contemporary problems and current research in financial management. Readings from current periodicals; problem and case analysis investigating those areas requiring financial decisions.

Management (Mgmt)

372. Introduction to Management Information Systems. (3-0) Cr. 3. F.S. *Prereq: 370; Com S 111 or 172 or 175.* Computer-based management information systems and how such an information system supports decision-making at all levels of management. The development, organization, management control, and evaluation of information system activities; societal implications of the use of the computer in business.

373. Applications in Business Information Processing. (3-0) Cr. 3. F.S. *Prereq: 370; Com S 201.* Design and development of business applications in COBOL. COBOL and its use in developing data processing applications, methods or storage for processing and information retrieval purposes, availability of generalized software packages, and the information interface with other functional areas of business.

374. Business Information Systems Analysis. (3-0) Cr. 3. S. *Prereq: 372.* Feasibility studies, identification of management decision requirements, approaches and techniques for the analysis and description of information flows, and managerial control of business system development.

470. Organization Theory. (3-0) Cr. 3. F.S. *Prereq: 371.* A macro view of organizations. Emphasis on the organization itself, rather than on people in organizations. Existing theoretical frameworks are employed to better understand why organizations are structured as they are and why they behave as they do.

471. Current Issues in Management. (3-0) Cr. 3. F.S. *Prereq: 371.* Current issues impacting on employer-employee relations; governmental, union, and societal influences. Emphasis on the nature of the current problematic issues, their impact, and alternative coping strategies.

479. Management Seminar. (3-0) Cr. 3. S. *Prereq: Senior classification in management, permission of the instructor.* Selected problems in management.

Marketing (Mkt)

440. Industrial Purchasing. (3-0) Cr. 3. F.SS. *Prereq: 340.* Principles and policies of industrial purchasing. Emphasis on materials management. Cases and a VAX interactive simulation.

444. Marketing Research. (3-0) Cr. 3. F.S.SS. *Prereq: 447; Stat 228.* Marketing research techniques: problem formation, research design, questionnaire construction, sampling, data collection procedures, and analysis and interpretation of data related to marketing decisions.

445. Sales Forecasting. (3-0) Cr. 3. S. *Prereq: 340; Stat 228 recommended.* Time series, analysis by regression, exponential smoothing, cycle analysis, and other mathematical models, by using an interactive program on a VAX terminal and case analysis.

447. Consumer Behavior. (3-0) Cr. 3. F.S.SS. *Prereq: 340.* Application of concepts and methods of the behavioral sciences to marketing management decision making.

449. Marketing Seminar. (3-0) Cr. 3. S. *Prereq: 447.* Analysis of current problems in marketing with emphasis on new theoretical and methodological techniques for solving these problems.

Transportation/Logistics (TrLog)

460. Logistics Management. (3-0) Cr. 3. F.S. *Prereq: 360.* Advanced business logistics, stressing materials management and quantitative approaches to design and operation of the total logistics system. Evaluation and solution of logistics cases.

462. Transportation Carrier Management. (4-0) Cr. 4. F.S. *Prereq: 360.* Functions, roles and management decisions for air, water, motor, railroad, and pipeline modes. Regulatory policies, ownership and management problems, pricing, labor, and competitive relationships.

464. Urban and Rural Transportation Management. (3-0) Cr. 3. F. *Prereq: 360.* Urban and rural passenger transportation from a managerial viewpoint. Analyses of transit operations, financing, marketing, personnel, and labor problems, federal and state aid, and a contrast between urban and rural transportation.

468. Transportation and Public Policy. (3-0) Cr. 3. F.S. *Prereq: 360, 462 and senior classification.* Analysis of current major issues and of pertinent studies on national policy, including recent and proposed legislation. Evaluation of impact of policy changes on carriers and economy. Individual projects required.

469. Transportation & Logistics Seminar. (3-0) Cr. 3. F.S. *Prereq: 460, 464, 468 and senior classification.* Research in contemporary problems in transportation and logistics.

Courses Primarily for Graduate Students, major or minor.

Mgmt 510. Business and Social Responsibility. (3-0) Cr. 3. F. *Prereq: 370.* Designed to stimulate critical evaluation of business' role in society; ethical, managerial, governance, and public issues as they affect the corporation.

Mkt 540. Advanced Marketing Management. (3-0) Cr. 3. S. *Prereq: 340.* Strategic marketing planning and decision making, with emphasis on use of quantitative techniques and marketing models.

Fin 550. Financial Management. (3-0) Cr. 3. F. *Prereq: 350.* Financial management problems; relationship of finance with other functions within the firm, including practical and theoretical methods of financial analysis as part of a system of management decisions.

TrLog 560. Transportation and Logistics Seminar. (3-0) Cr. 3. F. *Prereq: 360.* Management of transportation and logistics within contemporary business; case analysis used.

Mgmt 578. Management Policy Making. (3-0) Cr. 3. S. *Prereq: 540, 550, 560, 580; I E 551.* Formulation and application of management policy in organizations. Emphasis on analysis and solution of cases utilizing knowledge acquired in studying functional areas of business. Complexity of business problems and interaction of business functions.

Acct 580. Accounting Management. (3-0) Cr. 3. S. *Prereq: 285 or 381, permission of instructor.* Importance of accounting information in business decisions. Management's use of planning and control concepts as they apply to all types and functions of organizations.

BusAd 590. Special Topics. Cr. 1 to 5 each time taken. F.S.SS. *Prereq: Permission of instructor.* For students who wish to do individual research in a particular area of business.

A. Accounting
B. Finance
C. Management
D. Marketing
E. Transportation/Logistics

Ceramic Engineering

For description of courses, see *Materials Science and Engineering.*

Chemical Engineering

Maurice A. Larson, Chair of Department

The Graduate Faculty

Members: Abraham, Arnold, Bautista, Boylan, Burkhart, Burnet, Hill, Larson, Pulsifer, Reilly, Seagrave, Sheeler, Shuck, Ulrichson, Wheelock

Associate Members: Glatz, Jolls

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in chemical engineering, and minor work to students taking major work in other departments.

Prerequisite to major graduate work is the completion of an undergraduate curriculum substantially equivalent to that offered in chemical engineering at this institution.

The Master of Engineering degree requires an independent study project. A thesis is required for the Master of Science degree.

Interdepartmental programs between chemical engineering and biomedical engineering are provided under the sponsorship of the colleges of Engineering and Veterinary Medicine. Laboratory facilities are available in both biomedical engineering and chemical engineering. See *Biomedical Engineering.*

The department also participates in the interdepartmental program of Water Resources, and in the interdepartmental minor program of Energy Systems Engineering. (See Index.)

Courses for Graduate Students, minor only

320. Momentum Transport Operations. (3-0) Cr. 3. F.S. *Prereq: 210, Com S 172, Phys 221, credit or classification in Math 267.* Momentum and mechanical energy balances. Incompressible and compressible fluid flow. Applications to fluid drag, piping system design, filtration, packed beds and settling.

321. Heat and Mass Transfer. (3-0) Cr. 3. F.S. *Prereq: 320.* Conduction and diffusion, convective heat and mass transfer, boiling and condensation, radiation, simultaneous heat and mass transfer, design of heat exchange equipment.

322. Mass Transfer Operations. (4-0) Cr. 4. F.S. *Prereq: 321.* Analysis and design of continuous contacting and multistage separation processes. Binary and multicomponent distillation, absorption, extraction, evaporation.

324. Chemical Engineering Laboratory I. (0-2) Cr. 1. S. *Prereq: Credit or classification in 320.* Experiments covering basic chemical engineering measurements, material and energy balances, and momentum transport operations. Computer applications.

325. Chemical Engineering Laboratory II. (0-2) Cr. 1. S. *Prereq: 324, credit or classification in 321 and 332.* Experiments in heat and mass transfer, thermodynamics, and chemical reactor performance.

331. Chemical Engineering Thermodynamics. (4-0) Cr. 4. F.S. *Prereq: 210, Math 267, Phys 222.* Application of thermodynamic principles to chemical engineering problems. Energy and entropy balances. Thermodynamic properties of fluids, phase equilibria, chemical reaction equilibria.

332. Chemical Reactor Design. (3-0) Cr. 3. F.S. *Prereq: 331, credit or classification in 321.* Kinetics of chemical reactions, design of homogeneous and heterogeneous chemical reactors.

410. Chemical Process Industries. (3-0) Cr. 3. S. *Prereq: Chem 331.* Functioning of the chemical process industries: raw materials, process routes, intermediates, products, economics and marketing.

415. Biochemical Engineering. (3-0) Cr. 3. S. *Prereq: Chem 331.* Application of basic chemical engineering principles in biochemical and biological process industries such as fermentation, food processing, enzyme technology, and biological waste treatment.

421. Process Control. (2-2) Cr. 3. S. *Prereq: Credit or classification in 322, Math 267.* Control of industrial chemical processes. Devices applications and limitations. Dynamics of chemical process components and process control systems.

426. Chemical Engineering Laboratory III. (0-3) Cr. 1. F. *Prereq: 322, 325.* Investigation of chemical engineering process equipment.

430. Process and Plant Design. (2-6) Cr. 4. F. *Prereq: 322, 332.* Synthesis of chemical engineering processes, equipment and plants. Cost estimation and feasibility analysis.

441. Modeling and Simulation. (2-0) Cr. 2. S. *Prereq: 322, 332.* Simulation of behavior of chemical processes, trial and error calculations, numerical integration and other numerical methods. Problems involving fluid flow, distillation, heat transfer, process control, and reactor design.

442. Analog Computer Applications in Chemical Engineering. (1-3) Cr. 2. S. *Prereq: 322.* Applications of analog computers to the solution of problems arising in transport processes, chemical reactors, process dynamics, and equipment design.

443. Polymers and Polymer Engineering. (3-0) Cr. 3. F. *Prereq: 320, Chem 331.* Chemistry of polymers, addition and condensation polymerization. Physical and mechanical properties, polymer rheology, production methods. Fabrication and extrusion equipment operation. Applications of polymers in the chemical industry.

444. Applied Instrumentation. (2-4) Cr. 3. F.SS. *Prereq: Phys 222.* An introduction to measurement primarily for research students. Coordinated lecture and laboratory exercises in basic circuit theory, signal processing, recording and readout devices, and fundamentals of analog and digital instrumentation. Lecture/demonstrations illustrate practical aspects of instrument selection and use.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

515. Coal Science and Technology. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: Chem 321, 331.* Physical and chemical properties of coal, methods of analysis, and characterization. Industrial processes for cleaning, carbonizing, desulfurizing, gasifying, and liquefying coal to produce cleaner, more useful fuels.

521. Process Dynamics. (3-0) Cr. 3. S. *Prereq: 421.* Application of dynamic analysis techniques in the study of nonsteady state chemical processes.

530. Process Design and Optimization. (2-3) Cr. 3. S. *Prereq: 430.* Advanced process synthesis. Optimum seeking methods applicable to process design and evaluation.

531. Air Pollution. (Mteor 531). See Meteorology

532. Air Pollution Control. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 322.* Principles of gas purification and processes for the control of gaseous pollutants. Mechanics of aerosols and principles of particulate removal from gases.

545. Analytical and Numerical Methods. (3-0) Cr. 3. F. *Prereq: 322, Math 267.* Analysis of equipment and processes by analytic and/or numerical solution of descriptive differential equations. Operational and series techniques, boundary value problems, numerical interpolation and approximation, integration techniques.

552. Transport Phenomena and Momentum Transfer. (4-0) Cr. 3. F. *Prereq: 321, 331, Math 267.* Equations of change for mass, energy, and momentum according to phenomenological and molecular models. Introduction to transport in multicomponent systems. Exact and approximate solutions to the equations of motion. One-hour weekly demonstrations.

553. Heat and Mass Transport. (4-0) Cr. 4. S. *Prereq: 552.* Convective and radiative heat transfer, boiling, condensation, multicomponent diffusion, mass transfer models. High transfer rate effects. Simultaneous heat, mass and momentum transfer.

583. Advanced Thermodynamics. (4-0) Cr. 4. S. *Prereq: 331.* Application of thermodynamic principles to chemical engineering problems. Thermodynamic properties of non-ideal fluids and solutions; phase and chemical-reaction equilibria.

587. Advanced Chemical Reactor Design. (3-0) Cr. 3. F. *Prereq: 332.* Kinetics of heterogeneous reactions. Analysis and design of non-ideal flow and heterogeneous reactors.

590. Special Topics. Cr. 2 to 6 each time taken. Investigation of an approved topic on an individual basis.

595. Special Topics. Cr. 2 or 3 each time taken. *Prereq: Permission of instructor.* When offered with a letter suffix, the following letters are reserved for the topics listed.

A. Multicomponent Distillation
B. Solvent Extraction
C. Crystallization
D. Thermodynamics
E. Kinetics and catalysis
F. Transport Operations
G. Bioengineering

Courses for Graduate Students, major or minor

601. Seminar. (1-0) Cr. R. F.S. Offered on a satisfactory-fail basis only.

645. Advanced Calculation Methods for Chemical Engineers. (3-0) Cr. 3. *Prereq: 545.* Advanced analysis and design of equipment and processes requiring specialized mathematical techniques. Alt. S., offered 1983.

652. Advanced Momentum Transport. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 552.* Advanced topics in momentum transport and fluid mechanics including study of recent literature.

653. Advanced Mass Transport. (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 553.* Advaned topics in mass transport including study of recent literature.

654. Advanced Heat Transport. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 553.* Advanced topics in heat transfer including study of recent literature.

683. Non-Equilibrium Thermodynamics. (3-0) Cr. 3. Alt. SS., offered 1983. *Prereq: 552, 583.* Thermodynamics of irreversible processes including diffusion and sedimentation, electrochemical processes, muscle contraction, thermal diffusion, and membrane transport.

690. Advanced Topics. Cr. var.

699. Research.

Chemistry

Robert J. Angelici, Chair of Department

The Graduate Faculty

Members: Angelici, Barton, Corbett, Diehl, Edgar (Emeritus), Espenson, Fassel, Franzen, Gerstein, Gilman, Goetz (Emeritus), Hansen, Hoffman, Jacobson, D. C. Johnson, King (Emeritus), Kraus, Larock, Martin, McCarley, Powell, Ruedenberg, Russell, Spedding (Emeritus), Small, Struve, Svec, Trahanovsky, Verkade, Voigt, Warner, Wilhelm (Emeritus), Yeung

Associate Members: Hutton, R. P. Johnson, Kurtz

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in analytical, inorganic, organic, and physical chemistry, as well as the degrees Master of Science and Doctor of Philosophy in chemistry. Co-majors may be taken between areas within chemistry or between one of the areas in chemistry and another department. Courses in other areas of chemistry as well as courses in other departments may be used to satisfy the requirement for course work outside the major field. Minor work is offered to students taking major work in other departments.

The Department of Chemistry requires all graduate students majoring in chemistry to teach as part of their training for an advanced degree.

Prerequisite to major graduate work is the completion of undergraduate work in chemistry, mathematics, and physics, substantially equivalent to that required of undergraduate students at this institution.

For the Ph.D. degree, the foreign language requirement is reading proficiency in one of the following: German, Russian, French, or, in some special cases, Japanese.

Index to field of work is given by the second and third digits of course numbers:

(a) Inorganic Chemistry	00-09
(b) Analytical Chemistry	10-19
(c) Physical Chemistry	20-29
(d) Organic Chemistry	30-39
(e) General Chemistry	60-79
(f) Research	99

Courses for Graduate Students, minor only

301. Inorganic Chemistry. (4-0) Cr. 4. S. *Prereq: 324 or 321.* Bonding in inorganic systems; descriptive and systematic chemistry of the elements. Emphasis on correlation of structure and bonding with chemical or physical properties of inorganic compounds; applications of thermodynamics, kinetics, and other physical methods to study of inorganic systems.

***321. Physical Chemistry.** (3-0) Cr. 3. F.S. *Prereq: 210 or 211 or 178, Math 166 or Math 176, Physics 222 recommended.* Kinetic theory of gases, classical thermodynamics with applications to gases, multicomponent, multiphase equilibrium of reacting systems, surface chemistry, and electrochemical cells. Students majoring in chemistry or biochemistry will ordinarily elect Chem 324, 325.

321L. Laboratory in physical chemistry. (1-3) Cr. 2. F. *Prereq: Credit or classification in 321 recommended.*

***322. Physical Chemistry.** (3-0) Cr. 3. F.S. *Prereq: Chem 321 or 324.* Solids, transport properties, chemical kinetics; quantum mechanics, atomic and molecular structure, spectroscopy, statistical thermodynamics.

***331, 332. Organic Chemistry.** (3-0) Cr. 3 each. 331: F.S.; 332: F.S.; 332C: S. *Prereq: 331: 178 or 210 or 211, classification in 333A highly recommended; 332: 331, classification in 334A highly recommended.* Modern organic chemistry including nomenclature, synthesis, structure and bonding, reaction mechanisms, natural products, carbohydrates and proteins. For students majoring in physical and biological sciences, premedical and preveterinary curricula, chemistry and biochemistry.

401L. Inorganic Chemistry Laboratory. (0-4) Cr. 1. F. *Prereq: 301.* Preparation and characterization of inorganic and organometallic compounds by modern techniques. For students majoring in chemistry or biochemistry.

426. Radiotracer Methods. (2-0) Cr. 2. F. *Prereq: 322 or 325, Phys 112.* Radioisotope techniques and their applications to problems in biology and allied sciences. For students in biology and agriculture.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Advanced Inorganic Chemistry. (2-0) Cr. 2. F. *Prereq: 301.* Concepts of structure, bonding, and chemical reactivity applied to inorganic compounds of the metallic and nonmetallic elements. For students not majoring in inorganic chemistry.

501. Inorganic Preparations. (0-4) Cr. 1. F. *Prereq: 301.* Preparation and characterization of inorganic and organometallic compounds by modern research techniques.

504. Organometallic Chemistry of the Transition Metals. (2-0). Cr. 2. Alt. S. *Prereq: 301, 332.* Transition metal complexes of ligands such as cyclopentadienyl, olefins, acetylenes, benzenes, and carbon monoxide. Homogeneous catalysis.

505. Physical Inorganic Chemistry. (3-0) Cr. 3. F. *Prereq: 301 and 325 or 322.* Elementary group theory and molecular orbital theory applied to inorganic chemistry. Spectroscopic methods of characterization of inorganic compounds.

506. Systematic Inorganic Chemistry. (3-0) Cr. 3. S. *Prereq: 301 or 500 and 325.* Descriptive chemistry of the metallic and nonmetallic elements.

509. Introduction to Inorganic Chemistry Research. (1-0) Cr. R. F. Discussion of the various areas of current research in inorganic chemistry at Iowa State University.

510. Advanced Survey of Analytical Chemistry. (2-0) Cr. 2. F. *Prereq: 316.* Selected topics in modern quantitative analysis including analytical separations, titrimetry, spectroscopy, and other instrumental methods.

511. Advanced Quantitative Analysis. (3-0) Cr. 3. S. *Prereq: 316.* General methods of quantitative inorganic and organic analysis. Aqueous and nonaqueous titrimetry; selective reagents; sampling and sample dissolution; and analytical literature.

512. Electrochemical Methods of Analysis. (3-0) Cr. 3. F. *Prereq: 316, 325 and 325L.* Principles of convective-diffusional mass transport in electroanalysis. Applications of potentiometry, voltammetry, and coulometry. Introduction to heterogeneous and homogeneous kinetics in electroanalysis. Analog and digital circuitry. Interfacing.

513. Analytical Molecular and Atomic Spectroscopy. (3-0) Cr. 3. S. *Prereq: 316, 325, 325L.* Introduction to

physical optics and design of photometric instruments. Principles of absorption, emission, and fluorescence spectroscopy. Error and precision of optical methods. Ultraviolet, visible, and infrared methods of qualitative and quantitative organic and inorganic analysis.

516. Analytical Separations. (2-0) Cr. 2. F. *Prereq: 316, 325, 325L.* Principles and examples of inorganic and organic separation methods applied to analytical chemistry. Solvent extraction, volatilization, ion exchange, liquid and gas chromatography.

518. Advanced Quantitative Laboratory. (1-6) Cr. 3. S. *Prereq: 512, 513 and 516.* Instrumental methods of qualitative and quantitative chemical analysis.

520. Advanced Physical Chemistry. (2-0) Cr. 2. S. *Prereq: 322 or 325.* Principles of physical chemistry as they apply to analytical, inorganic, and organic chemistry, including thermodynamics, kinetics, quantum mechanics and spectroscopy. For students not majoring in physical chemistry.

521. Classical and Statistical Thermodynamics. (4-0) Cr. 4. F. *Prereq: 322 or 325.* Laws of thermodynamics and applications to multicomponent, multiphase, multireacting systems. Boltzmann distribution. Thermodynamic functions of monatomic and polyatomic gases.

522. Molecular Structure and Bonding. (3-0) Cr. 3. S. *Prereq: Phys 447.* Quantum mechanical variation principle. Molecular and atomic orbitals as function spaces. Chemical binding in H_2. Many-electron quantum mechanics. Anti-symmetry and determinantal electronic wave functions. Self-consistent-field approximation. Group theory in quantum chemistry. Angular momenta in atoms. Orbitals and states in many-electron atoms. Electronic structure of small molecules. Localization and electronic populations. Approximate self-consistent-field methods and semi-empirical treatments of large molecules.

523. Chemical Spectroscopy and Structure. (3-0) Cr. 3. F. *Prereq: 505 or 523, Phys 447.* Maxwell's field equations, interaction of electromagnetic radiation with matter including induced absorption and emission and spontaneous emission, microwave, infrared, Raman and electronic molecular spectroscopy, spectral lineshapes, introduction to solid state symmetry and structure.

524. Advanced Chemical Thermodynamics. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 521.* Advanced concepts in solution thermodynamics and phase equilibria.

525. Diffraction and Crystal Structure. (3-0) Cr. 3. Alt. S. offered 1982. *Prereq: 322 or 325.* X-ray neutron and electron diffraction scattering by electrons, atoms, and molecules. Data collection techniques, space group symmetry, application of Fourier methods, methods of phasing structural amplitudes.

526. Radiochemistry. (3-0) Cr. 3. Alt. S, offered 1982. *Prereq: 322 or 325.* Radioactivity, preparation and decay properties of radioactive nuclides, interaction of radiation and matter, chemistry of nuclear fission, instrumentation for measuring radioactivity, application of radioactivity to chemistry, especially to analysis.

527. Surface Chemistry. (3-0) Cr. 3. Alt. F, offered 1982. *Prereq: 322 or 325.* Basic principles and applications.

528. Chemical Kinetics and Mechanisms. (2-0) Cr. 2. S. *Prereq: 322 or 325.* Methods of studying reaction rates and mechanisms; inference of mechanisms from rate laws; reversible, consecutive, and competing reactions; chain mechanisms; exchange reactions; isotope rate effects; very rapid reactions; acid-base catalysis, theories of unimolecular reactions; absolute rate theory.

529. Introduction to Research in Physical Chemistry. (1-0) Cr. R. F. Introduction to the various areas of research in physical chemistry at Iowa State University.

530. Advanced Organic Chemistry. (2-0) Cr. 2. S. *Prereq: 332.* Selected topics in modern organic chemistry, including structure, reaction mechanisms, organic synthesis and spectroscopy. For students not majoring in organic chemistry.

531. Physical Organic Chemistry. (2-0) Cr. 2. F. *Prereq: 332.* Molecular structure, stereochemistry, kinetics, linear free energy relationships, introduction to reaction mechanisms, nucleophilic and electrophilic substitution reactions.

532. Spectrometric Identification of Organic Compounds. (1-3) Cr. 2. F. *Prereq: 332.* Principles of infrared, ultraviolet, nuclear magnetic resonance and mass spectroscopy as applied to organic chemistry.

533. Physical Organic Chemistry. (2-0) Cr. 2. S. *Prereq: 531.* Survey of reactive intermediates including carbonium ions, carbanions, carbenes and free radicals.

534. Modern Organic Synthetic Methods. (2-0) Cr. 2. S. *Prereq: 332.* A survey of modern organic functional group transformations.

535. Physical Organic Chemistry. (2-0) Cr. 2. F. *Prereq: 533.* Molecular orbital theory, molecular rearrangements, orbital symmetry, photochemistry and aromaticity.

536. Advanced Organic Synthesis. (2-0) Cr. 2. F. *Prereq: 534.* Synthesis of complex organic molecules and natural products.

570. (470 DL) Structure and Bonding. (2-0) Cr. 2. F. *Prereq: 325.* Graduate study in conjunction with 470. Not available for credit for students who have taken 470.

599. Nonthesis Research. Cr. arr. *Prereq: Permission of staff member concerned.*

Courses for Graduate Students, major or minor

600. Seminar in Inorganic Chemistry. (1-0) Cr. 1 each time taken. F.S. *Prereq: Permission of instructor.*

601. Selected Topics in Inorganic Chemistry. (2-0) Cr. 2 each time taken. F.S. *Prereq: Permission of instructor.* Topics such as chemical applications of group theory, molecular structure and bonding, organometallic compounds, physical techniques of structure determination, nonaqueous solutions, ligand field theory, solid state chemistry, and bio-inorganic chemistry.

611. Seminar in Analytical Chemistry. (1-0) Cr. 1 each time taken. F.S.

617. Mass Spectrometry. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: Permission of instructor.* Basic physics, instrumentation, and chemical applications of mass spectrometry.

620. Seminar in Physical Chemistry. (1-0) Cr. 1 each time taken. S. *Prereq: Permission of instructor.*

621. Statistical Mechanics. (3-0) Cr. 3 each time taken. Offered every third year, starting 1982 S. *Prereq: Permission of instructor.* Review of classical and quantum mechanics, principles of statistical mechanics, applications to thermodynamics and other related problems.

622. Quantum Chemistry. (3-0) Cr. 3 each time taken. Offered every third year starting 1982 F. *Prereq: Permission of instructor.* Construction of general electronic wavefunctions in many-electron systems. Spin eigenstates and spin adapted antisymmetric wavefunctions. Energy matrices and density matrices for general electronic wavefunctions. Natural and localized orbitals. Analysis of the self-consistent-field approximation. Discussion of various approaches to the correlation problem, configuration interaction method, pair theories, multi-configuration-self-consistent-field methods. Representative applications to atoms, molecules, and reactions.

623. Molecular Dynamics. (3-0) Cr. 3, each time taken. Offered every third year, starting 1983. S. *Prereq: Permission of instructor.* Phenomenological kinetics. Classical, semiclassical and quantum scattering theory (with emphasis on elastic scattering). Classical trajectories. Energy transfer collisions. Unimolecular kinetics. Reactive scattering. Experimental methods in molecular reaction dynamics.

624. Dynamics of Spectroscopic Transitions. (3-0) Cr. 3, each time taken. Offered every three years starting 1984, S. *Prereq: Permission of instructor.* Photophysical and photochemical relaxation process of molecular states and their implications for spectroscopic transitions.

625. Special Topics in Physical Chemistry. (2-0 or 3-0) Cr. 2 or 3 each time taken. F.S. *Prereq: Permission of instructor.* Topics such as atomic and molecular structure, surface chemistry, magnetic resonance, solid state spectroscopy, and chemical kinetics.

631. Seminar in Organic Chemistry. (1-0) Cr. 1 each time taken. F.S. *Prereq: 531, permission of instructor.*

632. Selected Topics in Organic Chemistry. (1-0) Cr. 1 each time taken. F.S. *Prereq: 531.* Topics of current interest in organic chemistry such as spectroscopy, physical organic chemistry, photochemistry, organometallic chemistry, mechanisms of oxidations and reductions, modern organic synthesis, reactive intermediates, heterocycles, and biosynthesis.

699. Research. *Prereq: Permission of staff member concerned.*

Child Development

Samuel G. Clark, Head of Department

The Graduate Faculty

Members: Clark, Pease

Associate Members: Crase, Draper, Fuqua, Galejs, Herwig, Lempers, Ragain, Stockdale, Sunderlin (Emeritus)

The department offers work for the degrees Master of Science and Doctor of Philosophy with a major in child development, and a minor for students taking major work in other departments.

In addition to fulfilling graduate college admission requirements, applicants should have substantial background in one of the following fields: child development, family relations, human biology, human nutrition, education, anthropology, psychology, or sociology. Emphasis areas within the department program may include: growth and development of children; research and teaching in child development; parent-child relationships; and early childhood programs.

There is no uniform foreign language requirement for the degree Master of Science or Doctor of Philosophy. In individual cases, however, competence in one or more languages may be specified by the student's program of study committee.

Courses for Graduate Students, minor only

342. Guidance of Children: Theories and Practices. (El Ed 342) (2-2) Cr. 3. F.S. *Prereq: 225, 226.* Behaviors of children in group situations. Basic theories of guidance applicable to children including the exceptional child. Principles and techniques for guidance of children. Participation with children in groups.

443. Curriculum Planning for Children. (3-0) Cr. 3. F.S. *Prereq: 341.* Examination, evaluation, and development of curricula for children. Principles and techniques involved in planning programs for children.

455. Programming for Children with Handicaps. (2-2) Cr. 3. S. *Prereq: 355, 369, 443.* Development of individualized, assessment-based programs for handicapped children. Methods for adapting materials, activities, and guidance. Participation with handicapped children.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

524. Principles and Theories of Child Development. (3-0) Cr. 3. F.S.SS. *Prereq: 6 credits in child development or psychology.* Historical and theoretical foundations of child development. Developmental approach to the study of child behavior. Basic principles, major theories, and research. Observation of children.

525. History and Theories of Early Childhood Education. (3-0) Cr. 3. F. *Prereq: 524 or 6 credits in child development or psychology.* History, theories, and trends in early education. Role of early education, including intervention models, in the total educational system.

541. Giftedness in Children. (3-0) Cr. 3. Alt. F, offered 1981, Alt. SS., offered 1983. *Prereq: 524 or 6 credits in child development or psychology.* History and theories of creative and intellectual giftedness. Characteristics of children with superior abilities. Assessment, current research, family and educational issues.

543. Developmental Disabilities in Children. (3-0) Cr. 3. F. Alt. SS., offered 1982. *Prereq: 524 or 6 credits in child development or psychology.* Characteristics of children with developmental disabilities: mental retardation, cerebral palsy, epilepsy, autism, and some forms of dyslexia. Consideration of cultural, familial, and educational influences and legal implications. Research on behavioral characteristics associated with developmental disabilities in childhood.

545. Planning and Administration of Programs for Children. (3-0) Cr. 3. S. Alt. SS., offered 1983. *Prereq: 525.* Objectives, procedures and research relevant to the administration and development of programs for children.

548. Parent-Child Relations and Parent Education. (3-0) Cr. 3. F. Alt. SS., offered 1982. *Prereq: 524 or 6 credits in child development or psychology.* Analysis of theories and research applicable to parent-child interactions; role of the parent as a socializing agent. Principles, procedures, current models and evaluation of parent education programs.

549. Child Rearing Practices Within and Across Cultures. (3-0) Cr. 3. S. Alt. SS., offered 1983. *Prereq: 524 or F E 575; or 6 credits in anthropology.* Analysis of child-rearing practices and life styles of subcultures within the United States and a variety of other cultures. An examination of current research on the child from a cultural perspective.

566. Research Methods in Child Development. (3-0) Cr. 3. S. *Prereq: 524, credit or classification in Stat 401.* Introduction to concepts, strategies, and methods of developmental research and assessment of children. Application of selected research strategies to current child development research. Experience in assessment procedures, methods of data collection, analysis, interpretation, and dissemination of findings.

590. Special Topics. Cr. arr. *Prereq: 6 credits in child development.*
A. Developmental Processes
B. Early Childhood Education
C. Community Services and Programs
D. Research
E. Professional Relations
F. Program Administration
G. College Teaching

Courses for Graduate Students, major or minor

616. Seminar. Cr. arr. F.S.
A. Current Issues in Child Care
B. Developmental Processes in Children
C. Developmental Appraisal of Children
D. Exceptional Children
E. Guidance of Children
F. Prenatal and Infant Development
G. Parent and Family Issues
H. Research Issues in Child Development
I. Eminent Persons in Child Development

630. Physical and Motor Development in Children. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 524.* Development of selected aspects of the structure and function of body systems in infants and children. Relationships of developing motor abilities to behavior. Identification and evaluation of theories, research, and assessments of physical development and motor performance.

631. Cognitive and Language Development in Children. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 524.* Theories of and empirical findings in the development of thinking and intelligence. Theories of language acquisition; research on syntactic and semantic development. Consideration of issues concerning interrelationships between cognitive development and developmental psycholinguistics.

632. Learning and Perceptual Development in Children. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 524.* Appraisal of theories and models of perceptual development with special emphasis on the role of innate versus experiential factors and on cross-modal perception. Fundamental concepts and principles of the development of learning. Consideration of issues concerning the role of perceptual factors in learning processes.

633. Social and Emotional Development in Children. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 524.* Consideration of theoretical and research contributions to the understanding of children's social and emotional development. Socialization processes and personality development.

699. Research.

Civil Engineering

Carl E. Ekberg, Jr., Head of Department

The Graduate Faculty

Members: Austin, Baumann, Brewer, Carstens, Cleasby, Demirel, Dougal, Ekberg, Greimann, Handy, Hardy, Hoover, Klaiber, Lee, Lohnes, Morgan, Oulman, Porter, Sanders, Sheeler, Spangler, Young

Associate Members: Fung, Jellinger, Kannel, Mickle, Ring, Russo, Wolde-Tinsae

The department offers work for the degree Master of Science with majors in civil, geotechnical, municipal, sanitary, structural, and transportation engineering, and in geodesy and photogrammetry; for the degree Doctor of Philosophy with majors in transportation, structural, sanitary and geotechnical engineering; and minor work to students taking major work in other departments.

Candidates for the degree Master of Science are required to satisfactorily complete 30 credits of acceptable graduate work, including preparation of a thesis or the completion of an engineering report in lieu of a thesis.

The department strongly recommends that all candidates for the degree Doctor of Philosophy demonstrate a significant level of proficiency in one of the following languages: French, German, Russian, or Spanish. However, with the approval of a doctoral candidate's program of study committee, 6 additional credits of course work outside the Department of Civil Engineering may be substituted for a language requirement.

The normal prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of engineering students at this University. However, because of the diversity of interests within the graduate programs in civil engineering, a student may qualify for graduate study even though undergraduate or prior graduate training has been in a discipline other than engineering. Supporting work will be required depending upon the student's background and area of interest. A prospective graduate student is urged to specify the degree program in which he or she is interested on the application for admission.

The department participates in the interdepartmental minor program in Energy Systems Engineering and in the interdepartmental programs in Technology and Social Change, Transportation Planning, and Water Resources. (See Index.)

Courses for Graduate Students, minor only

315. Geodetic Control Systems. (1-3) Cr. 2. F. *Prereq: 213.* Familiarization with geodetic instrumentation: theodolites, automatic levels, electronic distance measuring equipment, and accessories. Theory of geodetic control systems. Design of control networks, such as triangulation, trilateration, and leveling. Specifications for first, second, and third order systems. Introduction to adjustments.

317. Land Surveying. (1-3) Cr. 2. S. *Prereq: 213.* Review of public land survey systems. Modern land data systems. Field and problem work embraces the complete resurvey of a land parcel, including record search, preparation of plat and legal description. Case studies. Legal aspects.

332. Structural Analysis I. (2-2) Cr. 3. F.S. *Prereq: E M 324.* Shear and moment diagrams. Unit load method. Moment distribution. Approximate methods. Influence lines.

333. Structural Steel and Timber Design I. (2-2) Cr. 3. F.S. *Prereq: 332, E M 327.* Design and behavior of the elements of steel and timber structures, proportioning members and connections. Introduction to plastic design, composite design, and building and bridge loadings and design.

334. Reinforced Concrete Design I. (2-2) Cr. 3. F.S.SS. *Prereq: 332, E M 327.* Analysis and design of beams, one-way slabs, and columns. Preliminary design of building frames using pattern loading and moment coefficients.

350. Introduction to Transportation Planning. (3-0) Cr. 3. F.S.SS. *Prereq: 3 credits in statistics, junior classification.* Planning of urban and regional transportation systems. Applications of population, land use, economic, social, and travel studies to problems of transportation system configuration and route location. Organization and coordination of the transportation planning function. Not available for graduation credit for students in civil engineering.

351. Introduction to Transportation Engineering. (2-3) Cr. 3. F.S.SS. *Prereq: 213, Phys 221, Stat 105.* Introduction to planning and design of highway, air, rail, water, and pipeline transportation facilities. Technological and economic factors. Transportation terminals. Suggested for engineering students only.

360. Soil Engineering. (2-6) Cr. 4. F.S. *Prereq: Geol 301, credit or classification in E M 324.* Introduction to basic soil engineering and testing. Identification and classification tests, soil structure, soil mineralogy, soil water, systems, and interactive forces, aggregate gradation, absorption and blending; principles of settlement, soil bearing values, shearing stresses in soils and shear strength testing; application of soil engineering in subgrades, embankments, retaining walls, foundations, piles, and underground conduits.

362. Design of Concretes and Pavements. (0-6) Cr. 2. F.S. *Prereq: 360.* Physical and chemical properties of bituminous, portland, and other cements; mix design and testing of concretes; admixtures, mixing, handling, placing and curing, pavement thickness design.

370. Hydrology. (2-0) Cr. 2. S. *Prereq: Phys 111 or 221.* Introduction to hydrology and water resources including water sources, distribution, rainfall-runoff relations, streamflow, beneficial uses of water, and water requirements. For non-engineering majors.

371. Engineering Hydrology. (2-3) Cr. 3. F.S.SS. *Prereq: E M 378, Com S 172.* Elements of engineering hydrology, precipitation, infiltration, direct runoff, evapotranspiration, groundwater and streamflow; full pipe flow, open channel hydraulics, storm water collection; applications to engineering problems.

412. Survey Computation and Design. (2-0) Cr. 2. S. *Prereq: 315.* Error theory, adjustment theory, and least squares applied to geodetic control systems. Survey design principles derived from error propagation theory. Relationship to development of surveying control specifications.

414. General Photogrammetry and Photo-Interpretation. (For 414) See *Forestry.*

417. Subdivision Design and Layout. (2-2) Cr. 3. F. *Prereq: 213, 371.* Planning of residential subdivisions according to topography and specifications. Zoning and subdivision ordinances and platting laws. Surveying and engineering design computations.

418. Stereo-Photogrammetry. (2-3) Cr. 3. F. *Prereq: 414 or For 445.* Photogrammetric optics. Calibration. Geometry of aerial photos. Rectification. Stereo-plotter theory: paper print, projection-type and advanced. Comparators. Practice with projection-type plotter. Project planning and design of photogrammetric systems to achieve national map accuracy standards.

419. Principles and Techniques of Remote Sensing. (Aer E 419) See *Aerospace Engineering.*

426. Municipal Water and Wastewater Engineering. (2-4) Cr. 4. F.S. *Prereq: 371, Chem 167.* Potable water quality and quantity objectives, water sources and treatment methods; water pollution control objectives and treatment methods. Pumping storage and distribution of water. Wastewater quantities and collection systems.

446. Senior Structural Design Projects. (1-4) Cr. 3. S. *Prereq: 333, 334.* Building and bridge design in steel and concrete. Application of current building code and design specifications. Preliminary designs will include investigating alternative structural systems and materials. Final designs will include preparation of design calculations and sketches.

450. Traffic Engineering. (2-3) Cr. 3. F. *Prereq: 351.* Elements of highway and street traffic circulation and

planning. Driver and vehicle performance. Traffic analysis and traffic control. Lighting. Safety.

451. Urban Transportation Planning. (2-3) Cr. 3. S. *Prereq: 350 or 351.* Planning of highway systems and terminals as part of a complete planning approach; public transportation planning; transportation planning studies, projections, analysis, plan formulation, and programming.

452. Highway Design. (2-3) Cr. 3. F.S.SS. *Prereq: 351, 362, 371.* Design, construction, and maintenance of highway facilities; earthwork, drainage structures; pavements. Preparation of environmental impact statement. A complete design project is required.

460. Foundations. (3-0) Cr. 3. F.S. *Prereq: 360.* Fundamentals of foundation engineering. Exploration and site evaluation. Determination of allowable soil pressure. Selection of type, configuration of and structural design of foundations on sand, silt, and clay.

472. Applied Hydraulic Design. (2-3) Cr. 3. S. *Prereq: 371.* Charateristics of flow in natural and constructed channels; hydraulic design of culverts, bridge waterway openings, spillways, hydraulic gates and gated structures, pumping stations, and miscellaneous water control structures; flow measuring devices.

485. Engineering Construction. (2-2) Cr. 3. F.S. *Prereq: Classification in 332, E M 327.* Construction contracts, competitive bidding procedures, cost estimating, construction planning and scheduling for civil engineering projects. The critical path methods; equipment selection and production capabilities; falsework and concrete form work and cofferdam designs are covered.

486. Civil Engineering Specifications. (2-0) Cr. 2. S. *Prereq: Stat 105, credit or classification in Mgmt 315 or I E 480.* Contract documents, competitive bidding procedures for public work projects. Negotiated contracts for engineering design services. Preparation and interpretation of specifications for civil engineering projects.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates*

505. Public Works Engineering. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 426, 452.* The civil engineer's role in the public works field; municipal engineering and public works responsibilities in planning, financing, and in administering design, construction, operation, and maintenance of public facilities.

510. Analytical Photogrammetry. (2-0) Cr. 2. S. *Prereq: 513, 418 or For 445.* Concepts, principles, and methods of analytical photogrammetry. Coordinate transformation. Colinearity, coplanarity, and scale restraint conditions. Linearization of systems of equations. Computational methods. Adjustment of strips and blocks. Analytical plotters.

512. Geodetic Astronomy. (1-3) Cr. 2. F. *Prereq: 315, Math 265 or 275.* Celestial sphere and terrestrial coordinate systems. Coordinate transformations. Theory of precise determinations of latitude, longitude, azimuth, and time. Astronomical and instrumental corrections.

513. Adjustment of Observations. (2-0) Cr. 2. F. *Prereq: 315, 414, Stat 105.* Theory of errors. Error propagation in geodetic and photogrammetric systems. Observation and condition equations. Practice in the application of theory of least squares to adjustment of observations. Error analyses.

514. Fundamentals of Geodesy. (2-0) Cr. 2. F. *Prereq: 213 or Geol 302A.* General theory of geometric and physical geodesy. Applications of geodesy to scientific and engineering problems. Size and shape of the earth. Geometry of geodetic reference surfaces.

515. Physical Geodesy. (2-0) Cr. 2. S. *Prereq: 514, Math 266.* Gravity and potential theory. Geoid and other equipotential surfaces. Theory of geoidal undulations and deflections of the vertical. Isostasy. Gravity instrumentation and data reduction. Spherical harmonic and related analyses.

519. Remote Sensing of Earth Resources and the Environment. (1-3) Cr. 2. F. *Prereq: 419.* Review of the the theoretical basis of remote sensing, including photogrammetry and photo-interpretation. Remote sensing systems, including multispectral cameras, thermal mappers, multispectral scanners, microwave and radar imagers. Applications of remote sensing to resources, environment, and land use.

520. Fundamentals of Analysis and Treatment of Water. (2-3) Cr. 3. F. *Prereq: 426, Chem 211.* Physical and chemical processes in the analysis and treatment of water; includes adsorption, ion exchange, membrane processes, chemical precipitation, and gas transfer.

521. Fundamentals of Analysis and Treatment of Wastewater. (2-3) Cr. 3. S. *Prereq: 426, Chem 231, Micro 300.* Characterization of wastewaters relative to their treatability and selection of appropriate processes for their treatment.

522. Water Pollution Control Plant Design. (1-3) Cr. 2. S. *Prereq: C E 426, Chem 231, Biol 101.* Principles and design of physical, chemical and biological treatment processes, plant layout and hydraulic considerations.

523. Water Treatment Plant Design. (1-3) Cr. 2. F. *Prereq: 426, Chem 211.* Principles and design of conventional water treatment processes including coagulation, flocculation, sedimentation, filtration, disinfection and corrosion control. Plant layout and hydraulic considerations.

524. Solid and Hazardous Waste Collection and Disposal. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 371, 360.* Planning design and operation of solid and hazardous waste collections and disposal facilities including resource recovery and waste-to-energy systems.

531. Structural Analysis by Finite Elements. (3-0) Cr. 3. S. *Prereq: 533.* Use of the finite element method for the analysis of complex structural configurations. Plane stress, plate and shell finite elements. General purpose finite element programs. Newmark methods.

533. Structural Analysis by Matrix Methods. (3-0) Cr. 3. F. *Prereq: 332.* Analysis of structural problems by means of matrix formulation. Stiffness and flexibility methods. Direct stiffness method for 2-D frames, grids, 3-D frames. General purpose frame programs.

534. Classical Analysis Methods. (3-0) Cr. 3. F. *Prereq: 332.* Basic structural principles. Moment area, energy methods, unit load method, conjugate beam. Extensions to slope deflection and moment distribution. Non-prismatic members, temperature changes, axial load effects.

537. Dynamic Analysis of Structures. (3-0) Cr. 3. S. *Prereq: 533, E M 345.* Single and multi-degree of freedom systems. Free and forced vibrations. Linear and nonlinear response. Modal analysis. Response spectra. Computer programs for dynamic analysis. Seismic design.

539. Prestressed Concrete Structures. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 334.* Principles of prestressed concrete with applications to structural design.

540. Behavior of Reinforced Concrete Structures. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 334.* Behavior and strength of reinforced concrete members by reviews of experimental and analytical investigations; flexure, axial load, shear, bond, torsion; combined loadings.

544. Limit Analysis and Design. (3-0) Cr. 3. S. *Prereq: 333, 334.* Plastic analysis and design of steel beams and frames. Limit analysis and design for reinforced concrete beam and frame structures. Determination of ultimate loads and deflections by mechanism procedures. Considerations of hinging, ductility, and minimum weight design.

546. Advanced Structural Design in Metals. (3-0) Cr. 3. S. *Prereq: 333.* Design of built-up beams, plate girders, and heavy connections. Study of the theories of analysis of the behavior of structural metal members and the interpretation of specifications for the design of buildings and bridges.

547. Analysis and Design of Plate and Slab Structures. (3-0) Cr. 3. F. *Prereq: 334, E M 514, Math 266.* Bending and buckling of thin plate components in structures. Slab analysis by finite difference method. Analysis of shell roofs by membrane and bending theories.

549. Reinforced Concrete Design II. (2-2) Cr. 3. F. *Prereq: 334.* Design of long columns, floor slabs, building frames, and combined footings. Design considerations for torsion, biaxial bending, and structural joints. Introduction to cold-formed composite slab design and masonry design.

550. Advanced Highway Design. (3-3) Cr. 4. S. *Prereq: 452.* Rural and urban street and highway design. Establishment of design criteria, application to street and highway systems, and to intersections and interchanges; drainage design, urban freeway design aspects. Consideration of environmental interrelationships in route location and design.

552. Highway and Traffic Safety. (2-2) Cr. 3. S. *Prereq: 351.* Engineering aspects of highway traffic safety. Reduction of accident incidence and severity through highway design and traffic control. Accident analysis. Legal implications of safety in highway design, maintenance, and operation.

553. Advanced Traffic Engineering. (3-4) Cr. 5. F. *Prereq: 351.* Driver, pedestrian and vehicular characteristics. Traffic characteristics; highway capacity; traffic studies and analyses. Principles of traffic control for improved highway traffic service and safety. Traffic signals, signs, and markings; lighting; channelization; other traffic control measures.

556. Airport Planning and Design. (2-3) Cr. 3. F. *Prereq: Credit or classification in 452.* Airport planning including financing, activity forecasts, site selection, zoning, operation of landing and terminal areas. Drainage; geometric and structural design of runways, taxiways, and aprons.

557. Transportation Analysis and Forecasting. (2-3) Cr. 3. F. *Prereq: 451, Stat 331 or 401 or 446.* Travel studies and analysis of data. Travel projections. Public transportation forecasts and analyses.

558. Urban Transportation Development Laboratory. (1-2) Cr. 2. S. *Prereq: 350 or 351.* Study of designated problems in traffic engineering, urban transportation planning, and urban development. Forecasting and evaluation of social, economic, and environmental impact of proposed solutions; considerations of alternatives. Formulation of recommendations and presentation in the host community.

560. Soil Mechanics. (3-0) Cr. 3. F. *Prereq: 360.* Advanced treatment of theory and principles of engineering soil mechanics as related to permeability, capillarity, seepage forces, stress distribution, effective stresses, consolidation, shear strength, slope stability, earth pressure, bearing capacity, piles, and underground conduits.

562. Airphoto Interpretation of Engineering Soils. (2-3) Cr. 3. S. *Prereq: 360, Geol 301 or 302A.* Recognition, identification and mapping of engineering soils from airphotos. Site evaluation; material reconnaissance; principles and applications of infrared, radar, microwave technology; field checking.

563. Advanced Soil Engineering Laboratory. (2-3) Cr. 3. S. *Prereq: 565.* Analysis of soils and civil engineering materials by X-ray diffraction, differential thermal, thermogravimetric and electron beam methods.

564. Advanced Soil Engineering Laboratory. (1-6) Cr. 3. S. *Prereq: 560.* Triaxial shear, consolidation, permeability, capillary testing and analyses; relation of hydrostatic excess pressures to compositional influences. Field load tests.

565. Soil Behavior. (2-3) Cr. 3. F. *Prereq: 360.* Physico-chemical factors affecting soil stability, clay minerals, clay colloid chemistry and effects of chemical additives on behavior of soils and particulate systems. Determination of colloidal properties such as exchange capacity, zeta potential, capillarity and pore shape and size distribution.

567. Portland Cement Concrete Mixes and Pavements. (2-3) Cr. 3. F. *Prereq: 362.* Effects of cement chemistry and water-cement ratio, curing method, air entrainment, pozzolans, and other admixtures on concrete plasticity, strength and durability. Fibrous, light weight and high-density concrete. Elements of fatigue and creep. Principles of rigid pavement design.

568. Bituminous Materials and Pavements. (2-3) Cr. 3. S. *Prereq: 362.* Effect of chemical, physical and rheological properties of bituminous materials on mix and thickness design of flexible pavement systems. Durability, fatigue, performance evaluation, and rehabilitation of flexible pavements.

571. Surface Water Hydrology. (2-3) Cr. 3. F. *Prereq: 371.* Collection and analysis of hydrologic data concerning precipitation, infiltration, evapotranspiration, direct runoff and streamflow; theory and use of frequence analysis to hydrologic data; deterministic and statistical hydrologic models.

572. Water Resources Systems Engineering. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 371, I E 312.* Applications of systems analysis and operations research techniques to the planning, design, and operation of water resources systems; use of linear programming, network analysis, dynamic programming, and simulation as tools in solving water resources problems, use of deterministic and stochastic models in water resources planning and design.

573. Ground Water Hydrology. (2-3) Cr. 3. S. *Prereq: 371.* Ground water as a source of municipal, industrial, and agricultural water supplies; location, occurrence, hydraulics of flow; determination of aquifer and well characteristics, pumping test analysis; well design and pump selection; ground water basin management.

574. Multiple use of Water Resources. (2-0) Cr. 2. F. *Prereq: 371.* Social, economic, and technical phases of governmental participation in public works programs in the field of water resources; study of planning and design of multi-purpose water resources projects.

577. Water Resources I. (W Res 577) See *Water Resources.*

578. Water Resources II. (W Res 578) See *Water Resources.*

585. Highway Construction Methods. (2-0) Cr. 2. F. *Prereq: 362, 485.* Methods and equipment used in processing materials and constructing highways and their appurtenances; scheduling and controlling operations; compliance with specifications.

586. Heavy Construction Method. (2-0) Cr. 2. S. *Prereq: 485.* Methods and equipment employed in heavy construction including piles, caissons, heavy foundations, piers, cofferdams and river works, heavy concrete structures, retaining walls, tunneling and dam projects.

590. Special Topics. Cr. 1 to 5 each time elected F.S. Preclassification contract required.

Courses for Graduate Students, major or minor

616. Advanced Topics in Photogrammetry, Remote Sensing, and Image Interpretation. (2-0) Cr. 2 each time taken, maximum 6 credits. S. *Prereq: 510.* Study of advanced concepts in photogrammetry, remote sensing, and image interpretation, including satellite applications. Projecting systems. Advanced topics in data reduction and image processing.

618. Advanced Topics in Geodesy. (2-0) Cr. 2 each time taken, maximum 6 credits. S. *Prereq: 515.* Study of advanced concepts in geodesy, including satellite applications. Mathematical geodesy, including statistical methods. Advanced computational methods.

622. Advanced Topics in Water Pollution Control. Cr. 2 to 4. Alt. F., offered 1982. *Prereq: 522.* Study of advanced concepts in water pollution control. Analysis and application of current developments to pollution control methods.

623. Advanced Topics in Water Treatment. Cr. 2 to 4. Alt. F., offered 1981. *Prereq: 523.* Study of advanced concepts in water treatment. Analysis and application of current developments to water treatment methods.

649. Advanced Topics in Structural Engineering. (3-0) Cr. 3. F.S. *Prereq: Permission of structural graduate faculty.* Advanced concepts in structural engineering topics. Emphasis for a particular offering will be selected from the following topics: A. Behavior of Metal Structures, B. Design of Concrete Shells, C. Cable-Supported Structures, D. Advanced Matrix Analysis of Structures, E. Dynamic Design of Structures.

656. Planning Transportation Systems. (3-0) Cr. 3. S. *Prereq: 557.* Statewide, regional, and local transportation system planning. Development and calibration of models for travel forecasting. Concepts of the comprehensive, cooperative, continuing transportation planning process. Corridor travel planning.

660. Foundations and Underground Structures. (3-0) Cr. 3. S. *Prereq: 560.* Advanced foundation analysis and design to meet various soil conditions. Review of recent literature. Field investigation. Case histories. Reports.

663. Earth Dams. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 560.* Location, selection of materials, design, and construction of earth dams. Fee for field trip.

665. Stability of Soils and Granular Materials. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 560, 565.* Theoretical soil mechanics and mechanics of particulate media. Three dimensional stress space, strains and soil failure theories. Granulometry and colloid chemistry as related to soil strength, classification, and stabilization by chemical and physical means.

671. Advanced Topics in Water Resources Engineering. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 571, 572.* Study of advanced concepts and experimental techniques used in solving water resource engineering problems. Application of simulation methods in areas of hydrology, hydraulics of water control.

690. Advanced Topics. Cr. 1 to 3. Preclassification contract required.

699. Research.

***An undergraduate student must have an academic standing in upper one-half of his/her class in order to enroll in any 500-level civil engineering course.**

Construction Engineering

Administered by the Department of Civil Engineering

John G. Russo, Professor in Charge

Courses are offered for minor work to students taking major work in other curricula or in interdepartmental programs.

Courses for Graduate Students, minor only

346. Construction Estimating and Cost Control. (2-3) Cr. 3. F.S. *Prereq: 245, C E 215, and credit or classification in Acct 284 and I E 304.* Cost aspects of construction. Quantity takeoff methods, labor and equipment production rates, unit costs, overhead, and profit as they relate to the preparation of construction estimates. Creation and coordination of cost control systems with regard to engineering, estimating, construction, and accounting operations. Purchasing and subcontracting procedures for construction projects. Construction financing by owners and contractors.

371. Construction Organization and Management. (3-0) Cr. 3. F.S. *Prereq: 245.* Construction company organization, operation, and administration. Proper utilization and direction of manpower at the field and office level. Interactive processes necessary for efficient communication and resolution of field and office construction related problems.

372. Heavy Construction Equipment and Methods. (1-3) Cr. 2. F.S. *Prereq: 346, C E 360, I E 304.* Factors influencing the selection and purchase of construction equipment. Application of engineering fundamentals to performance and production and analysis of characteristics and capabilities of construction equipment. Methods of heavy construction. Project mobilization and site organization. Field trip and fee required.

440. Concrete and Steel Construction. (2-2) Cr. 3. F.S. *Prereq: 346, E M 324.* Planning and field engineering for concrete and steel construction. Design and construction of concrete formwork. Applications of formwork to concrete construction. Erection methods for structural steel systems. Field trip and fee required.

441. Construction Planning, Scheduling and Control. (2-2) Cr. 3. F.S. *Prereq: 346, Com S 172.* Planning and scheduling of construction projects. Computer applications to construction scheduling. Applications of scheduling to cost control and resource leveling.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

550. Construction Management Functions and Processes. (2-0) Cr. 2. F. *Prereq: 371.* Analysis of critical construction management and organizational systems, especially those involved in proper field and jobsite construction company operations. Emphasis on case studies and analysis of construction company operations.

565. Case Histories in Construction Documents. (3-0) Cr. 3. S. *Prereq: 371, I E 480.* Study of cases involving disputes encountered by management in construction contract documents. Analysis of common points of dispute and methods of avoiding disputes among the owner, architect, engineer, and construction contractor for a project.

570. Marketing Construction Services. (2-0) Cr. 2. F. *Prereq: 371.* Specific functions involved in marketing construction services. Need for construction marketing, market area and research, planning and objectives, operations, and personnel. Areas of image, publicity, jobsite arrangement, and promotional activity. Analysis techniques and analysis of existing construction company marketing systems.

590. Special Topics. Cr. 2 to 5 each time elected. F.S.SS. *Prereq: Permission of professor in charge.* Study and report preparation in selected areas of construction materials, equipment, operations, planning and scheduling, and management.

Community and Regional Planning

Riad G. Mahayni, Chair of Department

The Graduate Faculty

Members: Brooks, Mahayni

Associate Members: Knox, Lex, Malone

The department offers work for the degree Master of Community and Regional Planning with major in community and regional planning.

Degree requirements include completion of a 2-year, 52-credit program, including a thesis of 9 credits. Minor work is offered to students taking major work in other departments.

The program of graduate study is recognized by the American Planning Association.

By taking work in community and regional planning and by focusing on an area of concentration, a student may develop a program with his or her selection of a special emphasis from administration, economic planning, environmental planning, transportation planning, urban design, housing and neighborhood renewal, policy analysis, state and regional planning, social planning, and planning in developing countries.

For the degree master of community and regional planning, the foreign language requirement, if any, is established on an individual basis by the program of study committee.

Satisfactory completion of the core requirements and the acceptance of a thesis (9 credits) are required for the M.C.R.P. degree. In addition, the student is encouraged to complete 3 months of acceptable work experience in a planning office between his or her first and second year.

The department participates in the interdepartmental minor programs in Housing, Transportation Planning, and Technology and Social Change. (See *Index.*)

Courses for Graduate Students, minor only

380. Regional Planning and Metropolitan Development. (3-0) Cr. 3. F. *Prereq: 253 or 270.* Analysis of the growth and changes occurring in non-metropolitan and metropolitan regions; theories and functions of area-wide planning governance structures, policies and strategies for guiding development.

405. New Towns and Planned Communities. (3-0) Cr. 3. S. *Prereq: 253 or 270.* Survey of new town and planned community experience in the United States and abroad. Goals, objectives, and policy implications of new towns; various types of new towns and their social, economic, and governance structures. Review of appropriate legislation.

406. State Planning. (3-0) Cr. 3. F. *Prereq: 253 or 270, permission of instructor.* The state planning process; definitions, state policies; interrelationship of state, regional, and local policies; current practices; location of the planning function; obstacles to state planning.

416. Urban Design and Planning Practice. (3-0) Cr. 3. S. *Prereq: 272, permission of instructor.* Principles of urban design and their application to residential and commercial development.

432. Urban Development Planning and Programming. (1-9) Cr. 4. S. *Prereq: 272.* Utilization of the comprehensive planning process. Preparation of selected effectuating devices for the plans produced such as community revitalization projects, codes and ordinances, and capital improvement programming. Simulation of methods of analysis as applied to a specific geographic area.

492. Planning Law, Administration and Implementation. (3-0) Cr. 3. F. *Prereq: 253 or 270.* The basis in constitutional, common, and statutory law for the powers of plan effectuation. Problems of balancing public and private interests as revealed in the study of leading court cases. Administration of planning agencies and programs.

493. Environmental Law. (3-0) Cr. 3. S. *Prereq: 492.* Legal precedents, developments, and alternative policy approaches to protection, control, and development of the environmental rights, policies, regulations, and technology to land use and to water, air, and land poliution. Federal environmental control acts and leading federal court cases.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Topical Workshop. (1-9) Cr. 4. *Prereq: 272.* F. Planning problem; utilization of theory and methods in resolving planning issues. Topic changes every year.

511. Introduction to Community Planning. (3-0) Cr. 3. F. *Prereq: Permission of instructor.* Development of planning in the United States; history and evolution of the planning profession and constructs of current practice.

512. Planning Communication. (2-0) Cr. 2. F. *Prereq: Permission of instructor.* Methods of graphic, print, and media presentation for the planning professional with emphasis on technical report writing and presentation skills.

515. Housing and Public Policy. (3-0) Cr. 3. S. *Prereq: Permission of instructor.* Housing as an interdisciplinary issue: the economic, political, social, and physical restraints on housing and community development policy.

520. Planning Methods. (3-0) Cr. 3. F. *Prereq: 272 or graduate classification.* Basic foundation of planning methods and analytical techniques. Planning information sources and data and their use in the analysis of community issues. Application of scientific method to forecasting of demographic and land use variables.

522. Advanced Planning Methods. (3-0) Cr. 3. S. *Prereq: 272 or graduate classification.* Advanced foundations of planning methods and techniques. Analysis of economic base, input-output analysis, employment forecasting, transportation, use of computers and models in planning.

524. Historic Preservation Planning. (3-0) Cr. 3. F. *Prereq: Permission of instructor.* Planning methodology employed to further preservation objectives. Zoning, transfer of development rights, surveys, preservation plans, public and private financing of preservation.

527. Urban Social Planning. (3-0) Cr. 3. S. *Prereq: Permission of instructor.* Review and development of methodologies for planning programming and implementing social service delivery systems. Federal, state, and local approaches to social policy and planning.

529. Planning in Developing Countries. (3-0) Cr. 3. S. *Prereq: Permission of instructor.* A variety of planning and planning-related issues including rural-urban migration, development of national policies and programs, urban decay, rural development strategies, housing problems in a developing country.

531. Advanced Planning Workshop. (1-9) Cr. 4. F. *Prereq: 520 or 522.* Integration of planning methods and theory in dealing with a planning problem. Analysis of problem and formulation of strategies for implementation. Preparation of a planning report.

561. Seminar in Planning Theory. (3-0) Cr. 3. S. *Prereq: Permission of instructor.* Current planning theories: comprehensive land use, advocacy, participatory, radical, and transactive planning models. Decision making and organization model as they affect planning practice. Value conflicts and conflict resolution.

575. Urban Planning/Urban Management. (3-0) Cr. 3. F. *Prereq: Permission of instructor.* The role planning plays as a part of the management and decision-making process; policy initiation, development, and implementation; management approaches and tools.

590. Special Topics. Cr. 1 to 3. F.S.SS.
A. Urban Design
B. Historic Preservation
C. Environmental Planning
D. Urban Development Planning and Programming
E. Social Planning
F. Regional and Metropolitan Planning and Programming
G. State Planning
H. Housing
I. New Towns Planning
J. Planning in Developing Countries

592. Planning Law, Administration and Effectuation. (3-0) Cr. 3. F. *Prereq: Graduate classification in community and regional planning.* Process of administration and implementation of planning programs through planning law. Effective management of the urban environment. Powers and duties of planning authorities and the powers of plan effectuation; problems of balancing public and private interest as revealed in study of leading court cases.

Courses for Graduate Students, major or minor

699. Research. Cr. var. F.S.SS.

Computer Engineering

For description of courses, see *Electrical Engineering.*

Computer Science

Robert M. Stewart, Jr., Chair of Department

The Graduate Faculty

Members: Kafura, Keller, Lambert, Maple, Oldehoeft, Selman, Stewart, Zingg

Associate Members: Brearley, Eckstein, Grosvenor, Krishnaswamy, Strawn, Wright

The department offers work for the degrees Master of Science and Doctor of Philosophy with a major in computer science and minor work to students majoring in other departments.

Facilities exist for fundamental research in such areas as programming languages, computer architecture, operating systems, information structures and theoretical foundations.

A student desiring to do graduate work with a major in computer science should ideally have completed a bachelor's degree or equivalent in computer science. Students with a major in a related area such as electrical engineering or mathematics are also encouraged to apply.

For the degree Master of Science, 31 semester credits are required. Both thesis and non-thesis options are available. If no thesis is presented, the preparation of a paper demonstrating ability to organize and express significant ideas in computer science is required.

For the degree Doctor of Philosophy, a student is expected to demonstrate a high degree of proficiency in reading, writing and speaking skills. To insure such skills, the student must include in his program of study a demonstrated proficiency in either a foreign language or in communication skills.

All graduate students are required to pass a series of area examinations over the core areas of the graduate course offerings. The examinations are normally scheduled within the first two years of a student's graduate program.

The Department of Computer Science participates in the interdepartmental program Technology and Social Change. Students majoring in computer science may elect a minor in Technology and Social Change.

The Department of Computer Science recommends that all graduate students majoring in computer science teach as part of their training for an advanced degree.

Courses for Graduate Students, minor only

311. Data Structures and Algorithm Analysis. (3-0) Cr. 3. S. *Prereq: 211, 260.* Basic techniques for design and analysis of efficient algorithms; sorting, graph processing, and memory management algorithms. The investigation of a simple data base management system will provide an applications environment for topics discussed in this course.

332. Principles of Programming Languages. (3-0) Cr. 3. F. *Prereq: 211.* Organization of programming languages emphasizing their run time implementation. Introduction to formal specification of programming languages. Programming in several languages.

352. Introduction to Operating Systems. (3-0) Cr. 3. S. *Prereq: 211, Cpr E 384.* Survey of operating system issues. Introduction to hardware and software components including: processors, peripherals, interrupts, process and memory management, deadlocks, file systems, protection, virtual machines and system organization.

375. Applied Information Processing Systems. (3-0) Cr. 3. S. *Prereq: 111 or 175 and knowledge of COBOL.* Computer-oriented information systems concepts; introduction to systems analysis; working with a job control language; applying access methods; introduction to data base systems; batch and interactive projects using a business language.

411. Software Engineering. (2-2) Cr. 3. S. *Prereq: 311.* Principles and techniques for methodical construction of quality software. Software requirements and objectives; reliability; design methodologies; module specification techniques; testing and validation procedures; proof of program correctness. Emphasis on team projects.

432. Principles of Compiling. (3-0) Cr. 3. S. *Prereq: 260, 332.* Techniques of compiler and interpreter construction are studied. Lexical analysis, modern top-down and bottom-up parsing techniques, syntax directed translation, and code generation.

441. Computer Based Information Systems. (3-0) Cr. 3. F. *Prereq: 311, 352.* Advanced file concepts and access methods; data base management systems concepts and implementation; data dictionary structures; computer systems concepts for supporting data base systems; language considerations; computer center organizational structures; computer center information system project.

452. Implementation of Operating Systems. (2-2) Cr. 3. F. *Prereq: 352.* Laboratory course emphasizing the practical issues of operating systems design and implementation. Source code for a hierarchically structured system. Additions, replacements, or extensions to this system will be required as an individual or team project.

470. Computing Methods for Research Workers. (3-0) Cr. 3. S. *Prereq: 111 or 172 or 175 or graduate classification and one course in college level mathematics or statistics.* Role of computers in research. Use of computing facilities in research work. Structured problem solving and programming methods. General analysis of programming languages available for research. Use of utilities, command languages and files in research projects.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501. Computer System Architecture. (3-0) Cr. 3. F. *Prereq: 352.* Development of programming models of special purpose and general purpose computer systems. Alternative implementations of computer systems. Speed-cost tradeoffs, microprogrammed control.

507. Numerical Solution of Ordinary Differential Equations. (Math 507.) See *Mathematics.*

509. Computational Methods of Linear Algebra. (Math 509.) See *Mathematics.*

511. Principles of Algorithm Design and Analysis. (4-0) Cr. 4. F. *Prereq: 311.* Semantics of data structures; advanced data types; design, development and analysis of algorithms. Review of program structure; proofs of correctness.

521, 522. Theory and Design of Operating Systems. (3-0) Cr. 3 ea. 521: S. 522: F. *Prereq: 521: 501, 511; 522: 521.* Control of concurrent processes, primitives for process synchronization and communication, introduction to processor scheduling and queuing systems, file systems, protection. The detailed implementation of a fully functional operating system will be examined in support of these topics.

531, 532. Theoretical Foundations. (3-0) Cr. 3 ea. 531: F. 532: S. *Prereq: 531: 260; 532: 531.* Introduction to analytical methods and techniques used in the study of computer science. Finite automata and regular sets, context-free grammars, pushdown automata, Chomsky hierarchy, decidable and undecidable problems, primitive and partial recursive functions, basic recursive function theory and topics from general and automata-based complexity theory.

541, 542. Programming Languages. (3-0) Cr. 3 ea. 541: S. 542: F. *Prereq: 541: 432, 511 and 531; 542: 541.* Semantics of a wide array of programming language features; theory and practice of compilation of high level languages.

584. Digital System Organization. (E E 584) See *Electrical Engineering.*

585. Digital Systems Design. (E E 585) See *Electrical Engineering.*

589. Advanced Digital System Architecture. (E E 589) See *Electrical Engineering.*

590. Special Topics. Cr. arr. *Prereq: Permission of instructor.*

599. Nonthesis Research. Cr. arr.

Courses for Graduate Students, major or minor

610. Seminar. Cr. arr.

621, 622. Advanced Theory of Operating Systems. (3-0) Cr. 3 ea. 621: Alt. S., offered 1982, 622: Alt. S., offered 1983. *Prereq: 621: 522; 622: 522.* Advanced topics in the theory, design, and modeling of operating systems.

641. Semantic Models for Programming Languages. (3-0) Cr. 3. S. *Prereq: 542.* Interpretive, denotational, and logically based models of semantics; application of semantics to program correctness, language specification, and translation.

699. Research.

Construction Engineering

For description of courses, see *Civil Engineering.*

Dairy Science

For description of courses, see *Animal Science.*

Design Studies

Herbert W. Gottfried, Associate Dean of Design

The Graduate Faculty

Members: Brooks, Gottfried

Associate Members:

The following courses are offered for graduate minor work: 426, 490, 580.

Courses for Graduate Students, minor only

426. Criticism of Design. (3-0) Cr. 3. F.S. *Prereq: Arch 321 or Art 280 or CRP 383 or LA 271.* Developing and exercising a process of critical evaluation of designed objects varying in size and complexity.

490. Independent Study. Cr. 2 to 4 each time taken. *Prereq: Permission of instructor; advance reservation.* Investigation of an approved topic commensurate with the student's interest and ability.
H. Honors.

580. Advanced Interdisciplinary Studies. Cr. 2 to 5 each time taken. *Prereq: Permission of instructors.* An interdisciplinary approach to the examination of a topical issue of interest to the College of Design. Faculty from more than one discipline.

Earth Sciences

Bert E. Nordlie, Chair of Department

The Graduate Faculty

Members: Biggs, Chen, Hussey (Emeritus), Lemish, Nordlie, Palmquist, Roy (Emeritus), Seifert, Takle, Vondra, Yarger

Associate Members: Chen, Cody, DeLuca, Dobosy, S. Richardson, Windom

The department offers programs leading to the Master of Science and Doctor of Philosophy with majors in earth science, geology, and meteorology. The department also cooperates in the interdepartmental program in Water Resources (see Index). Students desiring a major in the above fields normally will have a strong undergraduate background in the physical and mathematical sciences. Individuals desiring to enter a graduate program are evaluated by considering their undergraduate preparation and their expressed goals.

Programs of study are designed on an individual basis in accordance with requirements of the Graduate College and established requirements for each departmental major. Minor work is normally taken in aerospace engineering, chemistry, computer science, engineering mechanics, mathematics, metallurgy, physics, soils, soils engineering, statistics, or zoology. Departmental requirements provide a strong, broad background in the major and allow considerable flexibility in the program of each individual.

A dissertation is required of all Ph.D. candidates. M.S. students normally are required to complete a thesis, although a nonthesis option is offered for the M.S. degree in earth science and in meteorology. The department requires all graduate students to do some teaching as part of their preparation for an advanced degree.

Candidates for the Ph.D. degree are required to submit proof of reading knowledge of two foreign languages or reading and speaking knowledge of one. The candidate's graduate committee may accept, as proof of mastery, either course grades in language courses taken at Iowa State University or a suitable score on a comprehensive examination.

Geography (Geog)

Courses for Graduate Students, minor only

324. Cultural Geography. (2-0) Cr. 2. F. Rahman. *Prereq: 3 credits in geography.* Origin, distribution and influence of cultural processes such as discovery, invention, evolution, and diffusion of phenomena on the landscape.

490. Independent Study. Cr. 2 to 4 each time taken. *Prereq: 2 credits in geography.*

495. Summer Field Study. Cr. 4 to 6. SS. *Prereq: 4 credits in geography, permission of instructor.* Correlated readings and field work. Four to six week field trip to a selected region in the U.S. or abroad to study cultural or physical geographic relationships. Written report required.

Geology (Geol)

Courses for Graduate Students, minor only

302A. Summer Field Studies. Cr. 6 to 8. SS. *Prereq: 231, 241, 355.* Vondra. 302A: Areal mapping; structural, stratigraphic, and geomorphologic analyses. Written reports with appropriate illustrations required. An 8-week summer field course required of all geology majors. Fee.

341. Determinative Mineralogy. (2-3) Cr. 3. F. *Prereq: 241, Phys 112 or 222 (preferred), Math 175.* Biggs. Technique oriented study of mineral determination. Relationships between crystallographic, chemical, and optical properties.

355. Structural Geology. (2-4) Cr. 4. S. *Prereq: 100 or 210; Phys 111 or 221 (preferred), Math 175.* Lemish. Description and classification of structures in sedimentary, metamorphic, and igneous rocks. Introduction to mechanical principles as related to deformational behavior of rock bodies in different environments. Laboratory includes application of geometrical techniques to solve structural problems; emphasizes map interpretation and use of stereonet.

365. Petrology. (3-4) Cr. 5. S. *Prereq: 302A, 341.* Biggs, Seifert. Nature and origin of igneous, sedimentary, and metamorphic rocks as a function of environmental conditions. Emphasizes description of rocks and conditions of formation. Microscopic study and classification of rocks in thin section.

380. Introduction to Geophysics. (3-0) Cr. 3. F. *Prereq: 302A, Phys 112 or 222 (preferred).* Sayre. Application of physical principles to determination of subsurface rock structure or boundaries or both. Includes seismology, gravitometry, magnetometry, and techniques of electrical and radioactivity surveying. Field application of geophysical methods to include data acquisition, computer processing and interpretation. Fee.

390. Geology of Iowa and the Midwest. (2-0) Cr. 2. SS. *Prereq: 15 credits in natural sciences.* Lemish. Evolution of stratigraphic, structural, and geomorphic features of Iowa and their economic significance. Primarily for teachers. Field trips.

398. Minerals, Rocks, and Fossils. (1-2) Cr. 2. SS. *Prereq: 15 credits in natural sciences.* DeLuca. Classification and significance of rock-forming minerals, crust-forming rocks and fossils as records of crustal evolution. Primarily for teachers. Field trip.

471. Erosion and Sedimentation. (4-2) Cr. 5. F. *Prereq: 302A and an introductory statistics course.* Palmquist, Vondra. Weathering; erosion and erosional surfaces, interpretation of landforms; source, dispersal, accumulation, and diagenesis of sediments in terrestrial, transitional, and marine environments. Field trips.

482. Economic Geology. (2-1) Cr. 3. F. *Prereq: 365.* Review of major ore concentration processes. Nature and origin of economic mineral deposits. Review of industrial mineral and fossil fuel deposits with major emphasis on metallic deposits. Lab: study of economic minerals and problems in mineral reserves.

484. Remote Sensing for Environmental Analysis. (Geog 484) (2-0) Cr. 2. Alt. F. *Prereq: 100, 210, or 301 or Geog. 100 or 202; concurrent enrollment in Geol 484L or Geog 484L.* Principles of remote sensing; interpretation of land patterns based on their physical, geologic, biologic and cultural images.

484L. Remote Sensing Laboratory. (0-2) Cr. 1. Alt. F. *Prereq: Concurrent enrollment in Geol 484.* Geomorphic, lithologic, and structural interpretation of remote sensing data.

486. Geology of North America. (3-0) Cr. 3. Alt. S. *Prereq: 355.* Geologic evolution of North America as interpreted from structural and stratigraphic relationships of the geological provinces.

Primarily for Graduate Students, major or minor, open to qualified undergraduates

534. Advanced Paleontology. (2-2) Cr. 3. S. *Prereq: 231, 471.* Cody, Vondra. Selected topics in paleontology and paleoecology: sedimentary environments and their effects on organisms, stratigraphic correlation, interpretation of earth history, advanced morphologic descriptions of fossils.

540. Mineral Chemistry and Physics. (3-0) Cr. 3. F. *Prereq: 341.* Windom. Fundamentals of crystal chemistry and application to common rock-forming minerals, especially silicates. Formation of elements, chemical bonding, polyhedral packing, crystallography, mineral genesis and metamorphism, physical properties of minerals.

544. Optical Mineralogy. (2-2) Cr. 3. S. *Prereq: 540.* Biggs. Theory of birefringence and transmission of light and related stimuli through crystalline matter. Optical properties of common mineral groups.

546. Clay Mineraology. (1-2) Cr. 2. S. *Prereq: 241.* Cody. Origin, geological significance, structure, and chemistry of clay minerals: techniques of identification and characterization of common clay and clay-size minerals.

550. Advanced Structural Geology. (1-2) Cr. 2. S. *Prereq: 355.* Lemish. Review of mechanical principles of rock deformation and development of secondary texture. Tectonic analysis and structural association. Stereonet, statistics, descriptive geometry, and map interpretation and contouring.

560. Advanced Petrology. (2-2) Cr. 3. S. *Prereq: 365.* Biggs, Seifert. Formation and alteration of rocks as function of environmental conditions. Phase equilibria, crystallization, magmatic evolution, diffusion, recrystallization.

564. Metamorphic Petrology. (2-2) Cr. 3. F. *Prereq: 560.* Seifert. Mineral assemblages and textures of contact; dynamic and regionally metamorphosed rocks; processes of recrystallization and deformation as a function of environmental conditions; regional patterns of metamorphic belts.

566. Sedimentary Petrology. (1-4) Cr. 3. S. *Prereq: 560.* Biggs. Origin, diagenesis, and petrologic implications of sedimentary rocks.

567. Solar System Planetology. (2-3) Cr. 3. Alt. F. *Prereq: 355, 365.* Richardson. Origin and evolution of the solar system, emphasis on meteorites and geologic evolution of terrestrial planets. Constraints on models of the early earth as derived from the petrology and dynamics of the Moon, Mars, Mercury, and Venus.

570. Principles of Stratigraphy. (3-0) Cr. 3. F. *Prereq: 231, 471.* Vondra. Basic concepts in stratigraphy, stratigraphic subdivision and nomenclature, correlation, facies and facies analysis, sedimentary tectonics, and basin analysis.

573. Quaternary Geology. (3-0) Cr. 3. S. *Prereq: 471.* Palmquist. Character and interpretation of landforms and sediments formed during the Quaternary. Field trips.

576. Clastic Sedimentation. (2-2) Cr. 3. S. *Prereq: 570.* Vondra. Interpretation of clastic sedimentary rocks to infer processes, environments, and tectonic settings under which they formed. Major clastic facies of selected regions studied and analyzed. Field trips.

577. Chemical Sedimentation. (2-2) Cr. 3. S. *Prereq: 471.* Cody. Survey of the origin and characteristics of recent and ancient chemical sediments: clays, carbonates, phosphates, zeolites, and sulfates.

580. Geomorphology. (2-0) Cr. 2. F. *Prereq: 471.* Palmquist. Processes and forms in surficial systems. Emphasis on fluvial and glacial systems.

582. Advanced Economic Geology. (3-0) Cr. 3. F. *Prereq: 482, 560.* Lemish. Review of major principles related to ore concentration and deposition. Geology applied to exploration and development of mineral deposits and fossil fuels. Problems related to ore genesis.

585. Geotectonics. (2-0) Cr. 2. S. *Prereq: 365, 471.* Windom. Global processes considered within the framework of plate tectonics. Continental drift, sea-floor spreading, the nature of the crust and mantle, island arcs and continental margins, magmatism and metamorphism, paleomagnetism and seismology.

586. Groundwater Geology. (2-2) Cr. 3. S. *Prereq: C E 371.* Sayre. Occurrence and distribution of subsurface water; nature of conducting media.

587. Mineral Equilibria. (3-0) Cr. 3. S. *Prereq: 588.* Windom. The phase rule and thermodynamic basis of mineral equilibria. Interpretation of geologically relevant phase diagrams including isobaric liquidus and subsolidus diagrams, pressure-temperature diagrams, log f_2-T diagrams and Eh-pH diagrams. Special emphasis on effect of pressure, both lithostatic and fluid, including P_{H_2O}, P_{CO_2}, P_S and mixed volatile fluids.

588. Geochemistry. (3-0) Cr. 3. F. *Prereq: 540; Chem 321 recommended.* Richardson. Elemental abundance patterns and geochemical cycles in the earth and oceans. Application of basic thermodynamic and kinetic principles to the study of geochemical processes.

589. Geochemical Instrumentation. (0-4) Cr. 2. S. *Prereq: 540.* Richardson. Instrumental methods for the analysis and charaterization of earth materials: microprobe, electron microscopy, atomic absorption, nuclear methods, and others.

590. Special Topics. Cr. 1 to 3 each time taken.

595. Seminar. Cr. R. F.S. *Prereq: Senior or graduate classification.*

Courses for Graduate Students, Major or Minor

699. Research. Cr. Var.

Meteorology

Courses for Graduate Students, minor only

301. General Meteorology I. (3-2) Cr. 4. S. *Prereq: Math 165 or 175, Phys 222.* Physical processes in the atmosphere including weather; instruments and observations, thermodynamics of dry and moist air, cloud physics, and radiation balance.

302. General Meteorology II. (2-3) Cr. 3. F. *Prereq: 301.* Fluid processes in the atmosphere including equations of motion, geostrophic and gradient flow, continuity equation, general circulation, concepts of weather map analysis.

341. Atmospheric Thermodynamics and Statics. (3-0) Cr. 3. F. *Prereq: Math 166 or 176, Phys 222.* Equation of state, first law of thermodynamics, thermodynamics of water vapor, mixtures of gases, stability, hydrostatic equation.

342. Physical Meteorology. (3-0) Cr. 3. S. *Prereq: 341.* Basic radiation laws, cloud physics, atmospheric electricity.

406. Climates of the Continents. (Agron 406) See *Agronomy.*

443. Fluid Processes in the Atmosphere. (4-0) Cr. 4. S. *Prereq: 341.* Development of the governing equations of motion. Concepts of divergence, circulation, and vorticity.

454, 455. Synoptic Meterology I, II. (3-3) (2-6) Cr. 4 each yr. *Prereq: 454: 443; 455: 454.* 454: Development of quasigeostrophic theory. Numerical prediction methods and linear perturbation theory. Applications to midlatitude synoptic systems. 455: Observational studies of tropospheric weather systems ranging in size from mesoscale to the planetary scale. Visualization and application of dynamic principles are stressed.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

505. Microclimatology. (Agron 505) See *Agronomy.*

528. Atmospheric Physics. (Phys 528) See Physics.

531. Air Pollution. (Ch E 531) (3-0) Cr. 3. S. *Prereq: Senior or graduate classification in engineering or the physical sciences.* Fundamentals of the formation, dispersion, and effects of air pollutants. Air quality standards, sampling and analysis, introduction to control methods.

542. Physical Meteorology. (3-0) Cr. 3. F. *Prereq: Math 266.* Propagation of energy through the atmosphere, atmospheric optics, visibility, aerosol physics, radar meteorology.

543, 544. Dynamical Meteorology I, II. (3-0) Cr. 3 each. Yr. *Prereq: 543: 443; 544: 543.* 543: Governing equations, scale analysis, simple types of wave motion in the atmosphere, instability theory. 544: General circulation and dynamics of zonally symmetric circulations, atmospheric energetics, nonlinear dynamics of planetary waves.

571. Cloud Physics. (3-0) Cr. 3. Alt. S. *Prereq: 342 or Phys 304.* Precipitation physics, thermodynamics of phase change and nucleation, condensation nuclei and ice nuclei, diffusional growth of cloud drops and ice crystals, accretional growth of cloud drops and ice particles.

590. Special Topics. Cr. Var.

Courses for Graduate Students, major or minor

605. Micrometeorology. (3-0) Cr. 3. Alt. F. *Prereq: 443.* Physical processes in the atmosphere near the ground; laminar and turbulent flow; transfer of heat, mass, and momentum; eddy diffusion; statistical theories of turbulence; wind and temperature profiles near the surface; evaporation.

641. Atmospheric Radiation. (3-0) Cr. 3. Alt. S. *Prereq: Math 266.* Solar and terrestrial radiation, radiative transfer equation, Stokes parameters, polarization.

699. Research. Cr. Var.

Economics

Raymond R. Beneke, Chair of Department

The Graduate Faculty

Members: R. D. Adams, Baumel, Beneke, Boehlje, Calkins, Davey (Emeritus), Enders, Faden, Fletcher, Fox, Fuller, Gardner, Harl, Harris, Hayenga, Heady, Hoyt, Huffman, Kolmer, Ladd, Lapan, Luckett, Mattila, Merrill, C. W. Meyer, W. H. Meyers, Miranowski, Murray (Emeritus), Paulsen, Prescott, Shepherd (Emeritus), Starleaf, Stephenson, Timmons, Weisskoff

Associate Members: J. W. Adams, Doak, Edwards, Futrell, Ginder, Gratto, James, Jolly, Julius, Scott, Skadberg, Stone, Thomas, Van de Wetering, Wisner

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in economics and agricultural economics, and minor work to students taking major work in other departments.

Prerequisite to major work in the department is the completion of undergraduate work in economics, mathematics, statistics, and other social science and technical subjects substantially equivalent to that required of undergraduate students majoring in economics or agricultural business.

Candidates for the degree Master of Science are required to complete satisfactorily 30 credits of acceptable graduate work, including preparation of a thesis.

With the approval of the program of study committee candidates for the degree Master of Science may fulfill requirements by satisfactorily completing 36 credits of course work, in which case preparation of a thesis is not required.

Programs of study for the doctorate are organized by each student in consultation with the major professor and the individual's committee. Students may select fields of concentration from the following: agricultural marketing and price analysis; agricultural production, finance, and policy; econometrics; economic growth, development, and planning; history of economic thought; industrial organization and regulation; international economics; labor economics; mathematical economics; monetary economics; natural resource economics; public finance; regional-urban economics.

Each student is expected to achieve a minimum competence in economic theory as demonstrated by completing basic and advanced courses in microeconomic and macroeconomic theory and by completing a written qualifying examination. Examinations are also required in two other fields selected from the list above. An outside minor, such as statistics, mathematics, or computer science, can be substituted for one of the fields.

Cooperative programs of study may be arranged with the University of Iowa College of Law or with other recognized institutions.

The department also cooperates in the interdepartmental programs of Industrial Administrative Sciences, Industrial Relations, Technology and Social Change, Transportation Planning, and Water Resources. (See *Index*.)

Courses for Graduate Students, minor only

401. Prices and Resource Allocation. (4-0) Cr. 4. F.S.SS. *Prereq: 201 or 204.* Theory of consumer demand and supply behavior of the business firm; competitive and imperfectly competitive markets. Theory of the demand for and supply of factors of production. General equilibrium analysis and welfare economics.

402. National Income and Employment. (3-0) Cr. 3. F.S.SS. *Prereq: 201 or 204.* National income accounting. Static and dynamic theories of the determination of income and employment. Analysis of the economic problems of inflation and unemployment. Monetary and fiscal policies for promoting economic stability and growth.

404. Labor Economics. (3-0) Cr. 3. F.S.SS. *Prereq: 201 or 204.* Survey of contemporary labor market problems and public policy towards labor. Economic analysis of topics such as labor supply and hours of work, work incentives of transfer programs, education and training, mobility, labor demand and employment, minimum wages, unions, income distribution and relative wages, discrimination, unemployment and wage inflation.

405. Public Finance. (3-0) Cr. 3. F.S.SS. *Prereq: 201 or 204.* Economics of public expenditures and taxation; federal, state, and local revenue and expenditure policies; current issues in public finance.

406. Marxian Economics. (3-0) Cr. 3. F. *Prereq: 201 or 204.* Economic theories of Karl Marx, including contributions and criticisms by other scholars. Topics include value, price, and distribution theory, business cycles, alienation of labor, and evolution of economic systems; applications to contemporary economies, including developing nations.

410. Economics of Antitrust and Regulation. (3-0) Cr. 3. S. *Prereq: 201 or 204.* Structure, conduct, and performance of industries. Analysis of American antitrust laws and government regulation of industries.

411. Economic Development. (3-0) Cr. 3. F. *Prereq: 201 or 204.* Current problems of developing countries, theories of economic development, agriculture and economic development, measurement and prediction of economic performance of developing countries, alternative policies and reforms required for satisfying basic needs of third world countries, interrelationships between industrialized countries and the developing countries.

***421. Cooperatives.** (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 201 or 204.* General survey of cooperative activities, with special reference to agriculture; kinds of cooperatives, methods of organization and operation; principles, legal requirements; economic possibilities and limitations of cooperation.

***430. Advanced Farm Decision-Making.** (3-2) Cr. 4. F.S. *Prereq: 330, 435; 451 recommended.* Effective use of quantitative methods and computer assistance for solving farm problems. Application of economic theory to production problems. Planning to account for changing prices and production and to meet government programs and policies. Using efficiency measures to assess and redirect resource use. Integrating tax management into farm business decision-making. Multi-period production and financial planning.

***435. Agricultural Finance and Investment Analysis.** (4-0) Cr. 4. F.S. *Prereq: 201 or 204.* Financial requirements of farm firms. Acquisition of debt and equity funds. Investment and cash flow analysis. Evaluation of credit needs and repayment capacity. Appraisal and valuation of real estate. Analysis of credit sources including commercial banks, insurance companies, merchants and dealers, Farm Credit System banks, Farmers Home Administration, Small Business Administration, and individuals.

***436. Agribusiness Firm Analysis.** (3-0) Cr. 3. F.S. *Prereq: 401, Stat 228.* Introduction to use of economic theory and quantitative techniques in analysis of agribusiness firms; formulation of decision problems, measurement of demand and cost relationships, forecasting techniques.

445. Collective Bargaining. (3-0) Cr. 3. S. *Prereq: 404.* Economic analysis and institutional aspects of unions and collective bargaining. Organizing, bargaining strategy, and contract terms; impact of unions on employment and wages. Public policy toward unions, strikes, and negotiated benefits in both the private and public sectors.

446. Economics of Discrimination. (WS 446) (2-0) Cr. 2. F. *Prereq: 201 or 204.* Economic theories of discrimination. Analysis of the economic problems of women and minorities in such areas as earnings, occupations, and unemployment. Public policy concerning discrimination.

***447. Agricultural and Rural Policy.** (3-0) Cr. 3. F.S. *Prereq: 201 or 204.* Description and analysis of economic problems of agriculture and rural communities. Explanation and economic analysis of government programs to develop agriculture and rural communities, stabilize and improve farm prices and incomes, plan rural land use, industrialize rural areas, control agricultural pollution, alleviate rural poverty, and regulate foreign trade.

***451. Agricultural Law.** (3-2) Cr. 4. F.S. *Prereq: Senior classification.* The legal framework impinging upon decision making by farm firms, families and individuals: real and personal property, organization of farm firms, intergeneration property transfers, trusts, insurance, liabilities, contracts, secured transactions, negotiable instruments, fence law, tax planning and management, water law, environmental law, federal and state regulatory powers.

455. International Economics. (4-0) Cr. 4. F.S. *Prereq: 201 or 204.* Analysis of pattern and benefits of international trade in relationship to employment, factor prices, and growth. International cartels, monopolies, and governmental policies toward trade, such as tariffs, quotas, and common markets. Balance of payments deficit, surplus, and exchange rate policies. Analysis of devaluations, international role of gold, Special Drawing Rights (SDR), fixed versus flexible exchange rates, history and reform of the international monetary system.

461. Urban-Regional Economics. (3-0) Cr. 3. F. *Prereq: 201 or 204.* Theories of urban development; city typologies, trade and commuting patterns; urban economic interdependence; social investment in metropolitan communities; regional growth and efficiency; locational determinants of firms and households; the regional economic base; resource development and economic planning in the city-region.

465. Economics of Educational Systems. (3-0) Cr. 3. Alt. S., offered 1982. SS. *Prereq: 201 or 204.* Economic problems of public education including production of services, resource use, allocative techniques among and within school systems, alternative measures of educational value, resource development through school systems.

***480. Intermediate Natural Resource and Environmental Economics.** (3-0) Cr. 3. S. *Prereq: 380, 401.* Theories of natural resource utilization and allocation. Externalities, public goods, and environmental quality. Planning natural resource use and environmental quality. Methodologies for analyzing natural resource and environmental problems.

495. Applied Microeconomics. (2-0) Cr. 2. F. *Prereq: 401, Stat 401, Math 150.* Study of microeconomic theory, with emphasis on business decision-making and statistical analysis. Consumer demand, cost minimization, pricing, and other strategic behavior.

496. Applied Macroeconomics. (2-0) Cr. 2. S. *Prereq: 402, Stat 401.* Application of macroeconomic theory to current economic problems. Analysis of economic policy.

*Administered by the College of Agriculture. Courses not marked with an asterisk are administered by the College of Sciences and Humanities.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Introduction to Graduate Studies. (1-0) Cr. R. F. Orientation course for new graduate students. Course content, ongoing research, and job opportunities in different areas of specialization in economics are discussed by the graduate faculty.

501. Intermediate Microeconomic Analysis. (4-0) Cr. 4. F.S. *Prereq: 401.* Economic theory and methodology; theory of consumer behavior; theory of competitive firm; partial equilibrium analysis and comparative statics; general equilibrium, economic efficiency and welfare; theory of imperfect competition.

503. Intermediate Macroeconomic Analysis. (3-0) Cr. 3. F.S. *Prereq: 402.* National income accounting, price indices, and the measurement of unemployment. Examination of the postulates and policy implications of the classical, neo-classical, Keynesian, and neo-Keynesian models of aggregate economic activity. Causes and consequences of price inflation.

504. Quantitative Methods in Economic Analysis. (4-0) Cr. 1. F. *Prereq: 401.* Economic applications of selected concepts of finite mathematics, differential calculus with emphasis on optimization, and integral calculus.

***512. Agrarian Reform and Economic Development.** (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 501.* Nature of agrarian institutions in obstructing and in achieving economic growth, income distribution and employment within developing countries. Improvements in factor and product markets, credit, ownership and tenancy systems, labor arrangements, inheritance systems, water rights and allocation, land measurement and titles, and other agrarian institutions through country, regional, intercountry, and United Nations actions. Comparative analysis of these institutions within countries: transfer and adaptation to other countries.

515. Industrial Organization Theory. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 401.* Theory and empirical studies of industrial structures and market practices in the American economy; measurement and evaluation of competition and monopoly.

516. Economic Aspects of Antitrust and Trade Regulation. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 515.* Legal manifestations of national economic antitrust and trade regulation policy; public intervention in industrial organization and price output policy; exemptions from antitrust law; price control; market divisions and agreements not to complete; refusals to deal; monopoly; merger; resale price maintenance; discrimination in distribution; unfair trade practices; remedies under antitrust law; effectiveness of antitrust policy.

***520. Human Capital Formation in Rural Areas.** (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 501.* Nature and process of human capital formation in households, firms and public institutions; labor supply and time allocation; application of benefit-cost analysis to human investments in agriculture; private and public costs and benefits of educational, health and mobility investments in rural people; distribution of human investment costs and benefits; demands for and capacity to provide human investment resources and facilities in rural areas.

***530. Applications of Mathematical Programming in Agriculture.** (2-0) Cr. 2. F. *Prereq: 430.* Techniques of building and solving linear programming models of agricultural problems; model building, solving problems with MPSX, and interpreting the solutions. Applications of interregional competition models and multigoal, integer, separable, and quadratic programming procedures.

***531. Agricultural Marketing Principles.** (3-0) Cr. 3. F. *Prereq: Credit or classification in 501.* Marketing firm choices concerning input acquisition, production, marketing, and plant location. Roles and impacts of market structures, information, grading, alternative coordination and ownership arrangements, futures markets, government regulation.

***532. Quantitative Research and Decision Models.** (3-0) Cr. 3. S. *Prereq: 501, credit or classification in Stat 401.* Use of statistical, economic, and other social science models to study marketing problems. Applications to public and private decision making.

***535. Economic Development and Transformation of Agriculture in Developing Countries.** (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 501.* Role of agriculture in economic development; relation of agricultural development to factor prices, firm structure and technology; role of government policies; firm behavior, and aggregate food response; improvement and communication of technology; capital supplies;

resource problems under various developmental stages; equity problems.

536. Dynamic Economic Analysis. (3-0) Cr. 3. S. *Prereq: 501, 503.* Fundamentals of dynamic economy theory; difference and differential equations and stability analysis, with emphasis on applications to macro and microeconomic theory; equilibrium and disequilibrium systems. Dynamic optimization techniques and applications to economic theory.

537. Linear and Nonlinear Economic Models. (3-0) Cr. 3. F. *Prereq: 401, 504.* Linear and nonlinear programming, input-output analysis, game theory, Markov chains, dynamic programming and other applied mathematical models in economics.

538. Econometric Statistics. (Stat 538) See *Statistics*.

539. Game Theory. (Stat 539) See *Statistics*.

544. Theory of Public Goods and Externalities. (3-0) Cr. 3. F. *Prereq: 501.* Public goods, externalities, theory of income redistribution, public choice.

545. Economics of Taxation. (3-0) Cr. 3. S. *Prereq: 501.* Partial and general equilibrium analysis of tax shifting and incidence; excess burden and effects of taxes on supplies of labor, capital, and risk-taking, alternate bases for taxation and concepts of equity; optimal taxation; economic effects of personal and corporate income taxes, payroll taxes, sales taxes, wealth and property taxes; the burden of debt; fiscal federalism.

***548. Agricultural Price Analysis.** (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 401, credit or classification in Stat 405.* Measurement of supply and demand of agricultural products. Use of forecasts in public and private decision-making.

551. Monetary Theory. (3-0) Cr. 3. F. *Prereq: 503.* The monetary mechanism: neoquantity theory; neo-Keynesian monetary theory and the portfolio approach; microeconomic aspects of monetary theory, including monetary determinants of cost of capital. Rate of interest, expectations, and lag in effect of monetary policy. Money supply theory.

552. Advanced Money and Banking. (3-0) Cr. 3. S. *Prereq: 503.* Advanced topics in monetary economics, including monopoly and competition in banking, models of commercial bank behavior, term structure of interest rates, instruments of monetary control, debt management, effectiveness of monetary policy.

555. International Trade. (3-0) Cr. 3. F. *Prereq: 501.* Modern theory of international trade; welfare and distributional aspects of trade and tariffs. The interdependence of international trade and economic growth. Optimal trade policies in the presence of such distortions as unemployment, monopolies and cartels, balance of payments problems, infant industries, and common market areas.

557. International Finance. (3-0) Cr. 3. S. *Prereq: 503.* Theory of foreign exchange; mechanisms of adjustment to balance of payments problems such as devaluations, monetary and fiscal policies, and exchange controls; international dependencies between domestic economies. Exchange speculation, evolution of the international monetary system, capital movements, the phenomenon of international inflation.

***561. Agricultural Resource and Income Problems.** (3-0) Cr. 3. F. *Prereq: 501.* Resource and income problems of U.S. and foreign agriculture. Forces for disequilibria, adjustment, instability, low and unequal resource productivity, poverty, income inequality, malnutrition, and international trade.

***562. Agricultural and Food Policies and Programs.** (3-0) Cr. 3. S. *Prereq: 561.* Description, analysis, and evaluation of domestic and international policies and programs influencing agricultural resource productivity and allocation; farm product, food and input prices; income distribution, world food situation; international trade in agricultural commodities.

565. Location and Regional Theory. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 501, 504.* Location of plants, industries and communities, network flows, spatial programming and optimization, regional input-output, spatial competition, land markets, influence of topography and resource distribution, innovation diffusion.

566. Regional-Urban Economics. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 501.* Theories of city growth, regional development models, central places and urban hierarchies, migration and commuting, city layout, CBD functions, problems of transportation, congestion, pollution and housing, public services.

568. Evaluation of Development Projects. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 501.* Review of standards for the planning and evaluation of natural resource and related development projects: traditional practices and recent innovations; economic and financial analysis; traditional investment criteria, project selection and investment programs; investment criteria for economic development; determination of the social discount rate, relation between classical welfare economics and cost-benefit analysis, treatment of externalities, secondary benefits and intangibles; traditional approaches to the valuation of labor, capital and foreign exchange; models of optimal economic growth and determination of national project evaluation parameters; integration of efficiency and equity into project selection, derivation and estimation of shadow prices; relationship between economic planning and the analysis of development projects.

573. Applied Econometric Models. (4-0) Cr. 4. F. *Prereq: Stat 405.* Selected applications of econometric techniques to models of consumer behavior, cost and production, demand for factors of production, the financial sector, and macroeconometric models. Selected topics of econometric problems encountered in applied econometric research.

575. Bayesian Econometrics. (3-0) Cr. 3. F. Offered twice every three years, offered 1981. *Prereq: Stat 447.* Difficulties with orthodox procedures, foundations of Bayesian inference, parameter estimation and forecasting, Bayesian and post-Bayesian hypothesis testing, regression models, simultaneous equations, Bayesian control models.

***579. Water Resources III.** (WR579) (3-0) Cr. 3. S. *Prereq: Permission of water resources supervisory committee.* Water resources planning. Water management categories and beneficial use groups; water demands for various uses. Legal, economic, sociological, governmental and technical aspects of water resources planning and management. Emphasis on systems of rational allocation among competing demands for water. Administered by Economics, in cooperation with Political Science and Sociology.

580, 581. Economic Development and Planning. (3-0) Cr. 3 each. Alt. yr., offered 1981-82. *Prereq: 580: 501, 503; 581: 580.* 580: Performance of developing countries in terms of output, equity and stability criteria; survey of theories and approaches to economic development; determinants of development; growth, value, and price in the labor surplus economy; choice of technique and technological change; sectoral balance and development strategies. 581: Planning models in relation to contemporary issues in economic development; techniques for sectoral analysis and planning; policy instruments and the evaluation of policy alternatives; organization and utilization of national and sectoral planning systems; applications to national, sectoral, and regional development problems.

585. Comparative Economic Systems. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 501, 503.* Analysis and comparison of economic theories, institutions, policies, and performance of alternative contemporary economic systems; emphasis on the economies of the Soviet Union, China, and Yugoslavia.

590. Special Topics. Cr. 1 to 5 each time taken.
*A. Agricultural Economics
B. Economics

595. Law of Labor Relations. (3-0) Cr. 3. F. *Prereq: 445.* Federal and state legislation and policies affecting the collective bargaining process, wages, and employment.

596. Labor Markets. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 501.* Modern analysis of labor demand and market determination of wages and employment; analysis of distortions in labor markets due to non-competitive forces, legislation, and discrimination; microeconomic analysis of unemployment and job search.

***Administered by the College of Agriculture. Courses not marked by an asterisk are administered by the College of Sciences and Humanities.**

Courses for Graduate Students, major or minor

601. Advanced Microeconomic Analysis. (3-0) Cr. 3. F.S. *Prereq: 501.* Advanced topics in consumer theory: compensating and equivalent variations, indirect utility functions; analysis of consumer and producer behavior under uncertainty; axiomatic approach to general equilibrium theory. Welfare analysis: compensation principles, theory of the second best. Intertemporal resource allocation, consumer and producer behavior.

603. Advanced Macroeconomic Analysis. (3-0) Cr. 3. S. *Prereq: 503.* Post-Keynesian consumption function hypotheses. Capital theory and the determinants of investment. The demand and supply of money. Stabilization policies. Models of long-term economic growth.

605, 606. History of Economic Thought. (3-0) Cr. 3 each. Alt. yr., offered 1982-83. *Prereq: 501, 503.* Principal figures in the development of economic ideas; contribution of each period of economic thought. 605: The Mercantilists to the Classical School, inclusive. 606: Critics of the Classical School to J. M. Keynes.

614, 615. Advanced Theoretical Models. (3-0) Cr. 3 each. 614; Alt. S., offered 1982. 615; Alt. F., offered 1982. *Prereq: 501, 504.* Selected topics in economic theory; decision-making under uncertainty, control theory, social choice theory, and measure theory. Economic applications: optimal growth under uncertainty, costly resource adjustment, optimal income distribution, and rational expectations. Introduction to the advanced literature, including relevant models from other social sciences.

***635. Theory and Concepts of Agricultural Finance.** (3-0) Cr. 3. F. *Prereq: 501.* Concepts of farm financial management and investment analysis: discounting techniques, capitalization theories, risk and diversification. Economic analysis of the capital market for agriculture: supply of and demand for debt and equity funds; processes of financial intermediation.

***641. Economics of Agricultural Production and Resource Allocation.** (4-0) Cr. 4. S. *Prereq: 501.* Production principles applied to agricultural labor, capital and natural resources; uncertainty and decision models; farm size, cost and productivity; commodity supply and resource demand; location and interregional competition; programming, simulation and other planning models; technological change; efficiency of agricultural production; macro and policy aspects.

651. Time Series. (Stat 651) See *Statistics*.

***680, 681. Advanced Natural Resource and Environmental Economics.** (3-0) Cr. 3 each. Yr. *Prereq: 680: 501; 681: 680.* 680: Nature, objectives, and problems of natural resource utilization and environmental quality. Economic, physical, and institutional interrelationships. Characteristics, criteria, and classes of natural resources. Interrelationships of natural resources and the environment with emphasis on capability of natural resources to absorb effects of environmental change. Demand for and supply of natural resources. Market and nonmarket considerations. Technological change. Private versus social decisions. 681: Quantification of decisions in managing natural resources and environmental quality. Objective functions, social costs and benefits, and intertemporal allocation. Policy analysis and evaluation for natural resource use and environmental quality; local, state, regional, national, and international levels; current and socially optimal policies; legal and social constraints.

690. Seminar. Cr. 1 to 3 each time taken. *Prereq: 6 graduate credits in chosen field.* Offerings each semester will be selected from the following list.
A. Industrial Organization
B. International Economics
C. Economic Development
D. Monetary Economics
E. Public Finance
F. Urban-Regional Economics
*G. Agricultural Marketing and Price Analysis
*H. Agricultural Development
I. Labor Economics

699. Research.
*A. Agricultural Economics
B. Economics

***Administered by the College of Agriculture. Courses not marked by an asterisk are administered by the College of Sciences and Humanities.**

Electrical Engineering

J. O. Kopplin, Chair of Department

The Graduate Faculty

Members: Basart, Boast (Emeritus), Brockman, Brown, Fanslow, Fouad, Hale, Hsieh, Koerber, Kopplin, Lakin, Mahmoud, Michel, Pohm, Post, Read, Smay, Swift, Thowsen, Zingg

Associate Members: Bond, Brearley, Burns, Camp, Carlson, Coady, Comstock, Day, Horton, Jones, Kruempel, Mamandur, Mericle, Musil, Nilsson, Piatkowski, Potter, Samuels, Scott, Stephenson, Townsend, Triska, Willett

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in electrical engineering and minor work to students taking major work in other departments. Minor work for electrical engineering majors is usually selected from a wide range of courses outside the Electrical Engineering Department. The department also participates in the Technology and Social Change and Energy Systems Engineering interdepartmental minors.

The degree Master of Science requires a thesis and is recommended for students who intend to continue toward the Doctor of Philosophy degree or to undertake a career in research and development. The non-thesis Master of Engineering degree requires an independent study project. Students pursuing a Doctor of Philosophy degree must select one of the following areas of specialization: electromagnetics, computer engineering, control systems, electric power.

The normal prerequisite to major graduate work in electrical engineering is the completion of undergraduate work substantially equivalent to that required of electrical or computer engineering students at this University. Because of the diversitication in the electrical engineering graduate program, however, it is possible for a student to qualify for graduate study in certain areas of electrical engineering even though his or her undergraduate or prior graduate training has been in a discipline other than electrical engineering. Supporting work, if required, will depend on the student's background and area of research interest. A prospective student from a discipline other than a curriculum in electrical engineering is urged to submit, with the application for admission, a statement of the proposed area of graduate study.

The department requires submission of GRE aptitude test scores by applicants from other countries. All students whose first language is not English must submit TOEFL examination scores.

Interdisciplinary programs between electrical engineering and biomedical engineering are provided jointly under sponsorship by the College of Engineering and the College of Veterinary Medicine. Laboratory facilities are available at the College of Veterinary Medicine, South Campus. (See *Biomedical Engineering*.)

Courses for Graduate Students, minor only

309. Electric Network Design. (2-2) Cr. 3. *Prereq: 206, 235.* Graphs and properties of gain and phase functions. Characteristics of tabulated filters. Scaling and transformations. Active network design. Elements of passive synthesis. All-pass networks.

313. Elementary Electromagnetics II. (4-0) Cr. 4. F.S. *Prereq: 212.* Magnetic forces and induction. Conduction. Electric and magnetic materials. Transmission lines in sinusoidal steady-state. Maxwell's equations. Uniform plane wave propagation and power flow in physical media. Reflection and transmission at normal incidence. Wave interference. Applications. Introduction to optical communication.

***330. Electronics I.** (3-3) Cr. 4. F.S. *Prereq: 205, 235.* Overview of semiconductor physics. Piece-wise linear modeling of diodes. D-C models for bipolar transistor and FET. Saturation and cutoff. Single time-constant switching circuits. Integrated circuit logic families. Comparators. Laboratory design projects.

***331. Electronics II.** (3-3) Cr. 4. F.S. *Prereq: 330.* Small-signal models and a-c coupled amplifiers. Power amplifiers. Linear operational amplifiers. Frequency response. Feedback. Laboratory design projects.

***351. Electromagnetic Devices and Electric Machinery.** (4-0) Cr. 4. F.S. *Prereq: Credit or classification in 313.* Magnetic circuit analysis. Iron core transformers. Force and torque calculations. Modeling of electromechanical systems. Introduction to electric machines. Modern motor control.

352. Electromagnetic Devices and Electric Machinery Laboratory. (0-3) Cr. 1. F.S. *Prereq: Credit or classification in 235, 351.* Experiments with electric and magnetic devices: force and torque measurements, transformers and their equivalent circuits, electric rotating machines, and the digital and solid state control of machines.

412. Electromagnetic Waves. (3-3) Cr. 4. F. *Prereq: 313.* Electromagnetic waves and energy flow in isotropic and anisotropic media. Reflection and refraction at normal and oblique incidence. Wave guides. Transmission-line models for uniform-plane and guided waves. Phase and group velocities, dispersion, and the ω-β diagram. Wave polarization. Principles of diffraction and applications to radiating apertures, Fourier optics systems, and synthetic aperture radar.

413. Transmission Lines and Microwave Engineering. (3-3) Cr. 4. S. *Prereq: 412.* Common microwave transmission lines. Impedance matching. Passive microwave structures. RF amplifier design. Microwave detectors and mixers. Microwave sources. Waveguide hardware.

416. Antenna Engineering and Radiowave Propagation. (3-3) Cr. 4. *Prereq: 412.* Radiation from elementary and extended current sources; wire antennas. Antenna theorems. Scattering. Receiving antenna and noise considerations. Array theory and design. Aperture antennas. Propagation fundamentals in point-to-point, radar, and scatter systems. Free-space, ground-wave, and ionospheric propagation, the atmosphere and noise, from VLF through millimeter wavelengths. Techniques and instrumentation for experimental studies.

421. Communication Systems I. (3-0) Cr. 3. F. *Prereq: 309.* Frequency domain analysis. Linear modulation: signals, receivers, transmitters. Frequency division multiplex. Angle modulation systems. Calculation of signal-to-noise ratios. System comparisons.

422. Communication Systems II. (3-0) Cr. 3. S. *Prereq: 421 and credit or classification in 423.* Sampling theorem and sampling practice. Pulse modulation systems. Quantization and pulse-code modulation. Time division multiplex. Information theory. Data transmission: spectral shaping, transmission impairments, and error rates. Comparison of modulation schemes for data transmission.

423. Communication Systems Laboratory. (0-3) Cr. 1. F. *Prereq: Credit or classification in 421.* Construction and evaluation of modulators, demodulators, and other components for analog and digital communication. Design and evaluation of a simple communication system.

433. Industrial Electronics. (2-0) Cr. 2. *Prereq: 331.* Use of thyristors and triacs in power control. The ideal thyristor in phase-control and zero-voltage switching. Applications to stabilized rectifiers, control of d-c and universal motors. Properties of real SCR's and triacs. Circuit protection.

434, 435. Analog Integrated Circuits. (3-3) Cr. 4 each. Yr. *Prereq: 434: 331; 435: 434.* Integrated circuit technology and its effect on circuit design. Internal stabilization. Operational amplifiers. A/D and D/A converters. Multistage amplifiers: frequency response, feedback, stability. Noise. Selected applications.

***436. Digital Integrated Circuits.** (3-3) Cr. 4. F.S. *Prereq: 330, Cpr E 280.* Modern logic families: comparison of the various technologies as to fabrication constraints, speed, and power. Integrated circuit memories. Design and implementation of digital logic systems and interfaces.

***437. Digital Integrated Circuits.** (3-0) Cr. 3. S. *Prereq: 330, Cpr E 280.* Integrated circuit fabrication principles; constraints on speed and power. Integrated circuit memories. Design of digital logic systems and interfaces.

***441. Introduction to Circuits, Instruments, and Electronics.** (3-2) Cr. 4. F.S.SS. *Prereq: Phys 222, Math 266 or 267.* Circuit analysis using network theorems and Laplace transform techniques. Transient and sinusoidal steady-state circuit behavior. Resonance. Semiconductor materials. Diodes. Transistor amplifiers. Operational amplifiers.

***445. Electronic Circuits, Instruments, and Systems.** (2-3) Cr. 3. S. *Prereq: 441.* Rectifiers and filters. BJT amplifiers. Field effect transistors. Differential and d-c amplifiers. IC fabrication. Bode plots. Feedback. Introduction to digital circuits.

***447. Introduction to Electric Machinery.** (1-3) Cr. 2. *Prereq: 441.* Magnetic circuits. Power transformers. Three phase circuit analysis. Basic principles of operation, design, and control of d-c, induction, synchronous, and single-phase machines.

450. Energy Systems. (2-0) Cr. 2. F. *Prereq: Senior classification in engineering.* Energy resources. U.S. and world energy supply and demand. Electric energy systems organization, structure, and operation. Economics of electrical generation. Environmental impact of energy systems.

451. Electrical Energy Sources. (2-0) Cr. 2. S. *Prereq: Senior classification in engineering.* A study of direct energy conversion devices and electrical energy storage methods with emphasis on their utilization in solar electric systems.

456. Power System Analysis I. (3-0) Cr. 3. F. *Prereq: Credit or classification in 351.* Power transmission lines, network analysis, power system representation, load flow.

457. Power System Analysis II. (2-2) Cr. 3. S. *Prereq: 456.* Power system operation, symmetrical components, faults, stability.

474. Linear Systems Analysis. (3-0) Cr. 3. F. *Prereq: Math 267, one course in circuits.* Writing equations for linear electrical and mechanical systems. State-space formulation. Solution of differential equations by transform methods. Block diagrams and signal-flow graphs. Feedback system characteristics. Root-locus, Bode, and Nyquist plots and their relationship to system stability. Analysis using Linear Systems Analysis Program.

475. Design of Linear Control Systems. (3-0) Cr. 3. S. *Prereq: 474.* Z-transform and its relation to Laplace transform. Block diagram algebra for sampled systems. Time response of sampled systems. Root-locus in the z-plane. Sampled-data analysis using Linear Systems Analysis Program. Computation in both continuous and sampled-data systems. Design projects.

476. Introduction to Analog Simulation and Computation. (1-3) Cr. 2. *Prereq: Math 267.* Basic concepts of analog computing. Time and amplitude scaling. Repetitive operation. Optimization. Applications to feedback systems.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

503. Advanced Network Theory. (3-0) Cr. 3. Alt. F. *Prereq: 206.* Graph theory and applications to network analysis. Matrix methods applied to multiport networks. State equations and methods of solution. Introduction to discrete time systems.

504. Network Synthesis. (3-0) Cr. 3. Alt. S. *Prereq: 309 or 503.* Properties of passive networks. Passive network synthesis. Properties of networks containing linear active elements. Synthesis of active networks with emphasis on two-ports.

510. Topics in Electromagnetics. Cr. 1 to 3. F.S. *Prereq: Permission of instructor.*

A. Antennas
B. Electromagnetic theory
C. Microwave engineering
D. Radio astronomy
E. Contemporary topics

511. Modern Engineering Optics. (3-0) Cr. 3 each topic. *Prereq: 412.* Each time offered, primary emphasis will be on one of the following topics.

A. Stimulated emission devices and systems: masers, lasers, and applications
B. Fourier optics and holography
C. Optical and hybrid optical-digital computers

512. Advanced Electromagnetic Field Theory I. (3-0) Cr. 3. F. *Prereq: 313.* Static electric and magnetic fields. Solutions of static field problems. Maxwell's equations. Circuit concepts and impedance elements. Propagation and reflection of plane waves in isotropic media. Guided electromagnetic waves. Characteristics of common waveguides and transmission lines. Propagation in anisotropic media.

513. Advanced Electromagnetic Field Theory II. (3-0) Cr. 3. S. *Prereq: 512.* Special theorems and concepts. Plane wave functions. Cylindrical wave functions. Spherical wave functions. Perturbational and variational techniques.

515. Physical Processes in Plasma. (3-0) Cr. 3. *Prereq: 313, Phys 325.* Ionization processes. Behavior of charged particles in electromagnetic fields. Self-sustaining processes. Breakdown, glow, arc, and corona. Plasma. Collision theory and Debye shielding. Liouville theorem and Boltzmann equation. Diffusion and mobility of weakly ionized gas. Plasma oscillations and waves. Diagnostics via Langmuir probe and electromagnetic waves. Thermionic and plasma diodes. MHD; plasma confinement.

516. Wave Phenomena in Plasma. (3-0) Cr. 3. *Prereq: 412, Phys 325.* Classification and propagation of waves in plasma. Waves in anisotropic magneto-plasma. Waves in a bounded plasma. Faraday rotation. Wave instability (convective vs. nonconvective). Nonlinear oscillations. Power flow and energy density. Interaction of electromagnetic waves with gaseous and solid-state plasmas. Plasma heating. Plasma-laser interaction. Instability in semiconductor plasma. Applications to semiconductor devices.

518. Radio Astronomy and Astrophysics. (Astro 518) (3-0) Cr. 3. *Prereq: 313 or Phys 365.* Radio astronomy fundamentals. Wave polarization and measurement. Radio telescope receivers and antennas. Wave propagation in plasmas. Synchrotron emission. Continuum and line spectra. Physical conditions in radio sources.

521. Random Signals and Noise. (3-0) Cr. 3. F. *Prereq: 474.* Elementary notions of probability. Random variables. Random processes. Gaussian random processes. Autocorrelation and spectral functions. Estimation of spectrum from finite data. Response of linear systems to random inputs. Wiener filter theory and extension to finite-data filters.

527. Statistical Communication Theory. (3-0) Cr. 3. *Prereq: 521.* Information theory of Shannon. Entropy. Noiseless coding. Channel capacity. Elementary error-correcting codes. Continuous channels. Hypothesis testing. Bayes and mini-max criterion. Detection of known signals. Matched filters. Quadrature receiver and equivalent forms. Detection of signals in colored Gaussian noise.

537. Semiconductor Device Theory and Technology I. (3-0) Cr. 3. *Prereq: 331, Phys 325.* Structure of solids. Wave mechanics. Band theory of solids. Semiconductors and semiconductor devices. Thermionic emission. Photoemission. Secondary emission. Photoconductivity. Luminescence.

538. Semiconductor Device Theory and Technology II. (3-0) Cr. 3. *Prereq: 537.* Metal-semiconductor diodes. P-N junction diodes. Junction transistors. Field effect transistors. Other semiconductor devices. Integrated circuit fabrication.

543. Energy Systems Engineering. (M E 543, Nuc E 543) (2-0) Cr. 2. *Prereq: One course in thermodynamics, E E 441, Econ 201 or 203 or I E 304.* Potentials and limitations of energy sources. Energy conversion, utilization, and conservation in industrial, residential, and transportation systems. Energy-related economic, environmental, social, and political considerations.

550. Advanced Electric Machinery. (3-0) Cr. 3. Alt. yr. *Prereq: 351, 352.* Analysis of machine transients. Modeling and control of multiphase and single-phase machines.

551. Operation and Control of Power Systems. (3-0) Cr. 3. Alt. Yr. *Prereq: 457.* Automatic generation control: load frequency control, economic dispatch. Constrained dispatch of real power. Reactive power dispatch. System monitoring.

552. Advanced Symmetrical Components. (3-0) Cr. 3. F. *Prereq: 457.* Computation of phase and sequence impedances of lines, machines, and transformers. Application of symmetrical components.

553. High Voltage Engineering. (3-0) Cr. 3. *Prereq: 457.* Basics of HV, EHV, and UHV transmission systems, line characteristics, configuration of conductors, high fields, ionization, AC and DC corona, voltage transients, lightning and protection, insulation coordination, circuit interruption, radio and TV interference.

554. Power System Dynamics. (3-0) Cr. 3. *Prereq: 457, 474.* Dynamic performance of power systems with emphasis on stability. Modeling of system components and control equipment. Analysis of the dynamic behavior of the system in response to small and large disturbances.

555. Analysis of Distribution Systems. (3-0) Cr. 3. *Prereq: 457.* Distribution components, design criteria, secondary networks, voltage control, protective device coordination, reliability analyses, load management and automation.

556. Computer Applications in Power Systems. (3-0) Cr. 3. Alt. Yr. *Prereq: 457.* Computer algorithms and methods for load flow, fault and stability analysis. On-line computing for power system operation.

557. Power System Protection. (2-3) Cr. 3. Alt. Yr. *Prereq: 552.* Elements of protective systems, relays and relaying schemes, circuit interrupting devices. Laboratory techniques and instrumentation for applications and experimental studies.

570. Systems Engineering Analysis. (3-0) Cr. 3. *Prereq: Credit or classification in Math 415.* Applications of selected topics in abstract algebra, linear algebra, theory of measure and integration, functional analysis, ordinary differential equations, optimization methods, and random processes in the areas of control and communication theory.

576. Discrete Time Control Systems. (3-0) Cr. 3. *Prereq: 474.* Operational and state-space methods applied to the analysis of discrete-time control systems. Compensation techniques. Analysis of nonlinear discrete-time systems. Optimization of discrete systems.

577. Modern Control Systems I. (3-0) Cr. 3. F. *Prereq: 474.* State variable and input-output description of linear continuous-time and discrete-time systems. Solution of linear dynamical equations. Controllability and observability of linear dynamical systems. Canonical descriptions of linear equations. Irreducible realizations of rational transfer function matrices. Canonical-form dynamical equations. State feedback. State estimators. Decoupling by state feedback. Design of feedback systems.

578. Modern Control Systems II. (3-0) Cr. 3. S. *Prereq: 577.* Nonlinear control systems. Lyapunov stability, Lagrange stability and input-output stability of continuous-time and discrete-time systems. Absolute stability, Popov criterion, and circle criterion. Estimates of trajectory behavior. Stability of large scale systems.

580. Contemporary Computer Networking and Data Communications. (3-0) Cr. 3. F. *Prereq: Graduate standing in electrical engineering, computer engineering, or computer science.* Survey of contemporary concepts, facilities, practices and issues in computer networking and data communications. Examples, network types, transmission technology, packet switching, routing protocols, flow control, security, network administration, performance and cost, reliability, social and legal considerations.

581. Design and Specification of Distributed Processing Systems. (3-0) Cr. 3. S. *Prereq: Cpr E 483.* Introduction to formal state-oriented techniques for the specification and analysis of digital communication and distributed data processing systems. Protocol validation and direct implementation techniques. System design based on hierarchical layering, canonical structure and canonical function.

582. Computer System Performance. (3-0) Cr. 3. *Prereq: 580 or Cpr E 385.* Introduction to measurement, simulation, queueing and probability theory techniques applied to quantify the performance and realiability of computer systems and networks.

583. Advanced Switching Theory. (3-0) Cr. 3. *Prereq: Cpr E 483.* Advanced topics in switching theory.

584. Digital System Organization. (Com S 584) (3-0) Cr. 3. *Prereq: Cpr E 384 or Com S 501.* Influence of processing requirements on digital system structure. Elements of information theory. Error detection and correction. Digital systems communications principles, including selected examples (Unibus, IEEE-488 bus). Interrupt-handling systems. Memory enhancement and virtual memory. Microprogrammed systems.

585. Digital Systems Design. (Com S 585) (3-0) Cr. 3. *Prereq: 584.* Perspectives on system design. Reliability. Redundant and fault-tolerant systems. Documentation standards. Test maintenance philosophy. Arithmetic processor design, including floating-point and pipelined units. Simulation languages. Packaging and power distribution. Clock and timing principles.

588. Advanced Microcomputer Design. (3-0) Cr. 3. *Prereq: Cpr E 487.* A study of microcomputer system design, involving both software and hardware details and trade-offs. An exhaustive survey of modern microprocessors.

589. Advanced Digital System Architecture. (Com S 589) (3-0) Cr. 3. *Prereq: Cpr E 385 or Com S 501.* Innovations in the architecture and organization of computing systems. Impact of technology on computer architecture. Trade-offs in alternative implementations of system features.

590. Special Topics. Cr. 1 to 6 each time elected. Formulation and solution of theoretical or practical problems in electrical or computer engineering. When offered with a letter suffix, a topic is designated as follows:
A. Electromagnetic theory
B. Control systems
C. Communication systems
D. Circuit theory
E. Computer engineering
F. Electric power
G. Electrical materials
H. Electronic devices and circuits

592. Seminar in Computer Engineering. Cr. 1 to 3 each time elected. *Prereq: Permission of instructor.*

593. Seminar in Control Systems. Cr. 1 to 3 each time elected. *Prereq: Permission of instructor.*

594. Seminar in Electric Power. Cr. 1 to 3 each time elected. *Prereq: Permission of instructor.*

595. Seminar in Electromagnetics. Cr. 1 to 3 each time elected. F.S. *Prereq: Permission of instructor.*
A. Antennas
B. Tropospheric and scatter propagation
C. Coherent optics
D. Plasmas
E. Microwave power
F. Remote sensing
G. Microwave engineering
H. Radio astronomy

Courses for Graduate Students, major or minor

610. Advanced Topics in Electromagnetics. Cr. 1 to 3 each time elected. F.S. *Prereq: Permission of instructor.*
A. Antennas
B. Electromagnetic theory
C. Microwave engineering
D. Radio astronomy
E. Contemporary topics

620. Error Detection and Correction. (3-0) Cr. 3. Alt. yr. as arr. *Prereq: 584.* Mathematical foundation of error detection and correction. Shift registers and pseudorandom sequences. Group codes, cyclic codes. Implementation of error detection and correction in digital systems.

624. Digital Signal Processing. (3-0) Cr. 3. Alt. yr. *Prereq: 474.* Discrete time signals and systems. Application of the z-transform to discrete-time systems. Discrete Fourier transform and its relation to discrete Fourier series and z-transform. Linear convolution using the DFT. Parameter quantization effects. Design techniques for IIR and FIR digital filters, including computer-aided methods, FFT algorithms and general computational considerations. Discrete Hilbert transforms and their applications. Discrete random signals. Effects of finite register length in the realization of IIR and FIR filters and DFT computations. Selected applications of digital signal processing techniques.

653. Advanced Topics in Electric Power Engineering. (3-0) Cr. 3 each time elected. *Prereq: Permission of instructor.* Advanced topics of current interest in electric power system engineering.
A. High voltage engineering
B. System planning
C. System dynamics
D. Probabilistic methods
E. Control and operation
F. Power electronics
G. Energy conversion
H. DC transmission systems
I. Lightning and switching surges

671. Optimal Estimation in Control Systems. (3-0) Cr. 3. Alt. Yr. as arr. *Prereq: 521.* Vector Gauss-Markov process. Discrete-time Kalman filtering. Modeling random processes in state form. Smoothing algorithms. Applications. Continuous-time Kalman filtering. Linearized and extended Kalman filter. Separation theorem of optimal control.

672. Optimal Control. (3-0) Cr. 3. Alt. yr. as arr. *Prereq: 578.* The optimal control problem. Variational approach. Pontryagin's principle, Hamilton-Jacobi equation. Dynamic programming. Time-optimal, minimum fuel, minimum energy control systems. The regulator problem. Structures and properties of optimal controls. Optimization by direct methods.

674. Advanced Topics in Systems Engineering. (3-0) Cr. 3 each time elected. *Prereq: Permission of instructor.* Advanced topics of current interest in circuit and control theory.
A. Circuit theory
B. System stability
C. Large-scale systems
D. System identification
E. Optimal control
F. Nonlinear systems
G. Stochastic systems
H. Discrete-time systems

685. Advanced Topics in Digital Systems. (3-0) Cr. 3 each time elected. *Prereq: 585.* Advanced topics in computing systems taken from current literature.

690. Advanced Topics. Cr. var.

699. Research. Cr. var.

Computer Engineering

Administered by the Department of Electrical Engineering

J. O. Kopplin, Chair of Department

A computer engineering graduate wishing to undertake graduate study will normally do so in electrical engineering or computer science. See *Electrical Engineering* and *Computer Science*.

Courses for Graduate Students, minor only

***340. Introduction to Digital Circuits and Systems.** (3-2) Cr. 4. F. *Prereq: Math 166 or 176.* Analysis of linear and piecewise linear resistive and resistive-capacitive circuits. Piecewise linear models for diodes, transistors, and operational amplifiers. Combinational and sequential logic. Logic elements. Digital representation of data. Design of digital subsystems.

384. Computer Organization and Design I. (Com S 384) (3-0) Cr. 3. F.S. *Prereq: 280, Com S 221.* Digital design languages and conventions. Descriptive realizations of digital computers. Microprogrammed control unit design. Contemporary MSI and LSI logic blocks. Arithmetic algorithms and realizations.

385. Computer Organization and Design II. (Com S 385) (3-0) Cr. 3. F.S. *Prereq: 340 or E E 205, and 384.* Input/output architectures. Programmed, interrupt, and direct memory access controlled data transfers. Interface design with peripheral devices and processors. Memory system architectures. Special purpose processor enhancement techniques.

387. Digital Laboratory II. (1-2) Cr. 2. F.S. *Prereq: 287, 384.* Use of advanced digital instruments. Experimental processor design. Bit-slice processor elements. Microprogramming experiments. Implementation of simple digital communication systems (software and hardware). Individual design projects.

***440. Computer Based Instrumentation and Control.** (3-2) Cr. 4. S. *Prereq: 340, or 280 and E E 205 or E E 441.* Introduction to computer based instrumentation and control. Logic devices, analog-to-digital and digital-to-analog converters, instrument buses (IEEE 488 and S100), personal computers, software support, system examples, data acquisition and control systems.

480. Digital System Design. (3-0) Cr. 3. F. *Prereq: 385.* Design of total digital systems including hardware and software. Specifications, life cycle costs, design cycles, documentation (flow charts, block diagrams, logic diagrams, timing diagrams, mechanical diagrams), automated design aids including MACSYM and automated layout programs, circuit and system problems including noise and reflections, design reliability and redundancy in systems, and the engineering and life-cycle costs of software including maintenance and documentation.

481. Digital Systems Design Laboratory I. (1-2) Cr. 2. F. *Prereq: 385, 387.* Experiments in the design of digital systems. Fee.

482. Digital Systems Design Laboratory II. (1-2) Cr. 2. S. *Prereq: 481.* Projects in digital system design. Fee.

483. Switching Theory. (3-0) Cr. 3. F.S. *Prereq: 280.* Analysis and synthesis of combinational and sequential circuits.

***487. Introduction to Microprocessors.** (3-3) Cr. 4. F.S. *Prereq: 384, E E 436 or 437.* Introduction to microprocessors. Microprocessor architecture and associated microcomputer systems. Consideration of peripheral systems parts and hardware/software tradeoffs. Software examples. Top-down designs are explored in a variety of examples.

488. Digital Systems: Digital and Nondigital Interfacing. (3-0) Cr. 3. *Prereq: 487.* Conversion of physical parameters to digital form; transducers. Digital data transmission; telemetry. Man-machine interaction. Interface design. Interface standards.

Elementary Education

Jess R. Beard, Head of Department

The Graduate Faculty

Members: Baum, Breiter

Associate Members: Abelson, Barnhart, Beard, Downs, Duffelmeyer, Henney, Kelly, Peterson

Graduate programs with a specialization in elementary education or learning disabilities and graduate certification programs in learning disabilities and emotional disabilities are administered through the Department of Professional Studies in Education.

Courses for Graduate Students, minor only

450. Ethnicity and Learning. (3-0) Cr. 3. *Prereq: 345.* Examination of the ethnically different learner in the classroom setting, with emphasis on cultural relevance in instruction.

451. Ethnicity and Learning Practicum. (1-4) Cr. 3. *Prereq: 450.* Field experience in a multi-ethnic classroom setting, with seminar discussion of these experiences.

457. Teaching Exceptional Learners in the Regular Classroom. (3-0) Cr. 3. F.S.SS. *Prereq: 250.* Emphasis on teaching techniques, teacher attitudes, and instructional modifications for mainstreaming exceptional learners (learning disabilities, emotional disabilities, mental disabilities, physically and perceptually handicapped, and gifted and talented children).

460. Evaluating Classroom Learning. (3-0) Cr. 3. *Prereq: 375.* Emphasis on application of both formal and informal achievement test data to classroom teaching practices.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

520. Teaching Strategies for Individualized Instruction. (2-0) Cr. 2. S.SS. *Prereq: 9 credits in behavioral sciences.* Analysis of current trends and practices for individualizing instruction.

521. Gifted Children and the Elementary School. (3-0) Cr. 3. F. *Prereq: 9 credits in education.* Survey of major areas of concern in the field of teaching gifted children.

522. Principles of Corrective Reading. (2-0) Cr. 2. F.SS. *Prereq: 375.* Identification, analysis, and correction of reading problems within the elementary program.

523. Principles of Corrective Mathematics. (2-0) Cr. 2. S.SS. *Prereq: 446.* Identification, analysis, and correction of mathematics problems within the elementary program.

524. Educational Interventions for Emotionally Disabled/Chronically Disruptive Children. (3-0) Cr. 3. *Prereq: Teaching certificate.* Analysis of current trends and practices. Emphasis on therapeutic intervention systems, behavioral manifestations, and etiology.

525. Analyzing the Educational Problems of Emotionally Disabled/Chronically Disruptive Children. (3-0) Cr. 3. *Prereq: Teaching certificate.* Individual educational diagnostic procedures and techniques.

526. Seminar: Research in Educational Procedures for Emotionally/Disabled/Chronically Disruptive Children. (2-0) Cr. 2. *Prereq: 524, 525.* Critical review of recent literature in education and psycho-behavioral sciences as applied to education of emotionally disabled/chronically disruptive children.

531. Teaching Gifted Children in the Elemtnary School. (3-0) Cr. 3. S. *Prereq: 9 credits in education.* Emphasis on teaching strategies and program development.

540. The Child with Learning Disabilities. (3-0) Cr. 3. F.SS. *Prereq: 9 credits in behavioral sciences.* Conceptualizations of characteristics of the learning disabled as well as possible etiologies of learning problems.

541. Teaching Strategies for Learning Disabilities. (3-0) Cr. 3. *Prereq: 455 or 540.* Analysis of techniques and materials for remedying specific learning disabilities.

590. Advanced Topics. Cr. 1-5. *Prereq: 15 credits in education; permission of department head.*

591A, 591B, 591C, 591D. Supervised Field Experience. (0-3 to 9) Cr. 1 to 6. F.S.SS. *Prereq: 15 graduate credits in special area.* Supervised on-the-job field experience in special areas. 591A: Learning disabilities. 591B: Emotional disabilities — mild. 591C: Emotional disabilities — moderate to severe. 591D: Gifted and talented.

593. Workshop. Cr. 1 to 5. SS. *Prereq: 15 credits in education.*

Courses for Graduate Students, major or minor

615. Seminar. (1 tc 3-0) Cr. 1 to 3. F.S.

699. Research. Cr. arr. *Prereq: 15 credits in education.*

Energy Systems Engineering

(Interdepartmental Minor)

William J. Cook, Chair of Supervisory Committee

Supervisory Committee: H. A. Cowles, R. T. Greer, J. D. Iversen, S. J. Marley, T. D. McGee, D. I. McKeown, A. H. Pulsifer, A. G. Potter, A. F. Rohach, J. C. Young

Minor graduate work is offered in energy systems engineering under a cooperative arrangement with various departments including Aerospace Engineering, Agricultural Engineering, Architecture, Chemical Engineering, Civil Engineering, Electrical Engineering, Engineering Science and Mechanics, Industrial Engineering, Materials Science and Engineering, Mechanical Engineering, and Nuclear Engineering.

Staff and facilities exist in several departments to assist the engineer with interest in bulk power or energy systems to pursue either advanced academic training or research. The departments named above are involved with energy systems and all offer graduate study and research opportunities. These include: fossil and nuclear power plants; transmission systems; power system analysis and control; utility rate structure, depreciation and valuation; engineering economics; energy supply and transport;

environmental impact of energy systems; materials utilization and processing; energy resources, conservation, conversion and utilization; and other energy related topics.

The normal prerequisite to minor graduate work in energy systems engineering is the completion of undergraduate work substantially equivalent to that required for engineering students at this University. Because of the diversity in energy systems engineering it is possible for students to qualify for graduate study in some of the above areas even though their undergraduate or prior graduate training has been in a discipline other than engineering.

Students minoring in energy systems engineering will select a block of courses from an approval list to achieve a stated energy-related objective. A member of the Energy Systems Engineering Supervisory Committee will serve on the student's program of study committee and will assist in defining a suitable minor program. The approved list of courses is available from the chairman of the supervisory committee.

Usually a block of 8 hours will be required as a minor for the master's degree and 12 hours as a minor for the doctoral degree. Energy Systems Engineering (E E, M E, Nuc E 543) shall be included in the student's program. The remainder of courses should be selected from those offered in two majors other than the student's major, at least one of which shall be outside the student's department.

Engineering Science and Mechanics

Harry J. Weiss, Head of Department

The Graduate Faculty

Members: Burger, Greer, McConnell, Munson, Nariboli, Riley, Rogge, Schmerr, Tsai, Weiss, Young

Associate Members: Akers, Graham, Holger, Huston, Johnson, Rudolphi, Sturges, Zachary

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with major in engineering mechanics, and minor work to students taking major work in other departments.

The Master of Science degree requires a thesis and a minimum of 8 research credits. It has strong research emphasis and is recommended for students who anticipate entering a doctoral program later. At least 30 hours of acceptable graduate work are required for the degree.

The Master of Engineering degree does not require either research credits or a thesis. However, at lease 2 credits of acceptable creative endeavor and at least 26 credits of acceptable graduate course work are required. A minimum of 30 credits of acceptable graduate work is required for the degree. The program is intended to give students additional instruction at the graduate level to better qualify them for advanced professional engineering work. By careful selection of electives and perhaps additional courses during the senior undergraduate year, students should be able to qualify for the master of engineering degree with an additional year of full-time study after receiving their baccalaureate degree in one of the several engineering curricula.

Credits for creative endeavor will be obtained by registering for E M 690M. The achievement will be determined by means of a written report and an oral presentation to the student's graduate committee.

The normal prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of undergraduate students in engineering at this University. However, because of the diversity of interests in graduate work in engineering mechanics, it is possible for a student to qualify for graduate study even though undergraduate or prior graduate training has been in a discipline other than engineering — e.g., physics or mathematics.

Cooperative programs between Engineering Mechanics and Biomedical Engineering are provided jointly under the sponsorship of the Colleges of Engineering and Veterinary Medicine. Laboratory facilities are available in both the Biomedical Engineering Building and the Laboratory of Mechanics. See *Biomedical Engineering* for requirements. The department participates in the interdepartmental minor program in Energy Systems Engineering. (See Index.)

Courses for Graduate Students, minor only

301. Fundamentals of Mechanics. (4-0) Cr. 4. F.S.SS. *Prereq: Phys 221, Math 166.* Newton's laws, equilibrium of rigid and deformable bodies, stress. Kinematics and dynamics of particles and rigid bodies. Deformation and strain of solids and fluids, constitutive equations for solids and Newtonian fluids. Applications to tension, torsion, flexure of solid bars and vibrations. E M 301 can not be used for credit toward graduation for students who have completed E M 324 or E M 345 or their equivalent.

324. Mechanics of Materials. (3-0) Cr. 3. F.S.SS. *Prereq: 274.* Plane stress, plane strain, stress-strain relationships, and elements of material behavior. Application of stress and deformation analysis to members subject to centric, torsional, flexural, and combined loadings. Elementary considerations of theories of failure, buckling, repeated and impact loads.

***327. Mechanics of Materials Laboratory.** (0-3) Cr. 1. F.S.SS. *Prereq: 301 or credit or classification in 324.* Experimental determination of mechanical properties of selected engineering materials. Experimental verification of assumptions made in 301 and 324. Use of strain measuring devices. Preparation of reports.

***337. Engineering Materials.** (M S E 337) (2-3) Cr. 3. F.S.SS. *Prereq: 301 or credit or classification in 324.* Properties, uses, and manufacture of metals, timber, stone, clay products, cements, concrete, and other engineering materials. Laboratory work similar to 327 with additional topics and added emphasis on concrete.

345. Dynamics. (3-0) Cr. 3. F.S.SS. *Prereq: 274, Credit or classification in Math 266 or 267.* Particle and rigid body kinematics, Newton's laws of motion, rigid body kinetics. Work-energy, linear and angular impulse-momentum, rotating coordinates, Coriolis acceleration. Applications to gyroscopic motions. impact and vibrations.

370. Principles of Nondestructive Testing. (M S E 370) See *Materials Science and Engineering.*

370L. Nondestructive Testing Laboratory. (M S E 370L) See *Materials Science and Engineering.*

378. Mechanics of Fluids. (2-2) Cr. 3. F.S.SS. *Prereq: 274 or 301.* Properties of fluids. Fluid statics. Kinematics and kinetics of fluid flow. Impulse-momentum, dimensional analysis, flow in pipes and channels, engineering applications. Selected laboratory experiments.

417. Experimental Mechanics. (2-2) Cr. 3. F. *Prereq: 301 or 324.* Introduction to experimental methods in mechanics with application to practical engineering problems. Strain measurement methods, transducer applications, recording and output devices, motion measurement methods. Selected laboratory experiments.

425. Introduction to the Finite Element Method. (3-0) Cr. 3. S. *Prereq: 301 or 324, Math 266 or Math 267.* Introduction to finite element analysis with applications to problems such as stress-deformation analysis, fluid and heat flow, potential flow, torsion, wave propagation. Use of simple codes for computer solution of problems.

444. Mechanical Vibrations. (2-2) Cr. 3. F.S. *Prereq: 324, 345, knowledge of FORTRAN.* Elementary vibration analysis, single and multiple degrees of freedom, energy methods, free and forced vibrations, viscous damping, transmissibility, influence coefficients, matrix methods, lateral vibrations of beams. Selected laboratory experiments.

451. Engineering Acoustics. (M E 451) (2-2) Cr. 3. F.S. *Prereq: Phys 221 and Math 266 or 267.* Sound sources and propagation. Noise standards and effects of noise on man. Principles of noise and vibration control used in architectural and engineering design. Characteristics of basic noise measurement equipment. Experience in use of noise measuring equipment, sound power measurements, techniques for performing noise surveys, evaluation of various noise abatement techniques applied to common noise sources. Laboratory and field experiments.

484. Principles of Similitude and Modeling. (2-2) Cr. 3. F.S. *Prereq: 301 or 324, a fluids course.* Dimensional analysis and modeling. Principles governing the design and operation of models for solution of engineering problems. Analogies.

***Students who are not present for the first laboratory meeting of their own sections may qualify for continuation in the course only by attending the first laboratory meeting of some other section of either of these two courses.**

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

504, 505. Analytical Methods in Mechanics. (3-0) Cr. 3 each. Yr. *Prereq: 504: Math 385; 505: 504.* Applications of the equations of heat conduction, potential theory, and wave propagation to problems in mechanics. Methods of solution.

514. Advanced Mechanics of Materials. (3-0) Cr. 3. F. *Prereq: 324.* Theory of stress and strain, stress-strain relationships. Limitations of flexure and torsion formulas, unsymmetrical bending, curved beams, cross-shear, shear center. Torsion of thin-walled noncircular sections. Theories of failure, membrane stresses in shells, thick-walled cylinders.

515. Stability. (3-0) Cr. 3. S. *Prereq: 324.* Stability of colums, beam-columns, bars and frames. Inelastic buckling, torsional buckling, bending and buckling of thin plates and shells.

516. Applied Elasticity. (3-0) Cr. 3. S. *Prereq: 514.* Basic equations of plane elasticity theory, Airy stress function and Prandtl torsion function with applications. Virtual work, least work, and other energy methods.

517. Experimental Stress Analysis. (3-2) Cr. 4. S. *Prereq: 324.* Fundamental concepts of strain measurement, properties of stress coat and its application, wire, foil, and semiconductor strain gages, strain gage circuits and recording instruments, rosette analysis. Two- and three-dimensional photoelasticity, compensation techniques, principal stress separation using shear difference, oblique incidence and other methods, birefringent coatings, scattered light, design of models, moire methods, introduction to holography.

519. Experimental Methods of Motion Measurement. (2-2) Cr. 3. Alt. S., offered 1983. *Prereq: 417, 444.* Description, specifications, limitations, and applications of mechanical, electrical, and optical transducers used in motion measurements applied to steady state, transient, and shock motions. Calibration, signal conditioning, and transducer systems used to obtain reliable and reproducible experimental data. Seismic and absolute references for motion measurement.

520. Biomechanics. (B M E 520) Cr. 3. S. *Prereq: Phys 111 or 221, Math 265.* For students with interests in the life sciences who wish to obtain background in applied mechanics. Equilibrium, vibratory motion, stress and deformation, material properties, flow of fluids, dimensional analysis and modeling of biological systems. Examples taken from biology and medicine.

525. Finite Element Analysis. (3-0) Cr. 3. F. *Prereq: 324.* Application of the finite element method to problems of engineering. Plane strain and plane stress problems of solid mechanics. Potential problems related to fluid mechanics and heat transfer. Viscous flow problems. Element shape functions for plates and shells. Introduction to the boundary solution procedure.

537. Experimental Fluid Mechanics. (M E 537) See *Mechanical Engineering.*

544. Mechanical Vibrations. (2-2) Cr. 3. F. *Prereq: 324, 345.* Elements of lumped parameter linear systems, kinematics of vibrations, equations of motion for free and forced vibrations, energy methods, resonance, damping, multiple degrees of freedom, mechanical impedance, isolation and absorption of vibrations with impulsive and arbitrary excitation of linear systems, primary and residual shock spectra.

546. Introduction to Random Vibrations. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 544.* Characteristics of random vibrations; random processes, probability distributions, spectral density and its significance, the normal or Gaussian random process. Transmission of random vibration, response of simple single and two-degree-of-freedom systems to stationary random excitation. Fatigue failure due to random excitation.

548. Advanced Engineering Dynamics. (3-0) Cr. 3. F. *Prereq: 345, Math 266 or 267.* Dynamics of particles and rigid bodies. Orbital motion. Generalized coordinates. Lagrangian equations of motion. Equations of motion in terms of Eulerian angles, motion of a gyroscope. Applications to engineering problems.

549. Vehicle Dynamics. (3-0) Cr. 3. Alt. S. offered 1982. *Prereq: 345, Math 266 or 267.* Theory and engineering principles of road and off-road ground vehicles. Analysis and evaluation of performance characteristics, handling behavior, and ride qualities.

551. Noise Source Analysis. (M E 551) (2-2) Cr. 3. S. *Prereq: 444 or 451, a fluids course, Math 385.* Analysis of basic noise sources including typical noise source mechanisms for rotating machinery, fluid-structure interactions, internal and external flows. Techniques used in noise source identification including analog and digital frequency analysis.

555. Biomedical Fluid Mechanics. (B M E 555) (3-0) Cr. 3. S. *Prereq: 520.* Applications of principles and concepts of fluid mechanics to problems in biology and medicine. Hemodynamic characteristics of the circulation, rheology of blood flow in the microcirculation, flow in the large arteries, and the respiratory system.

560. Scanning Electron Microscopy Characterization of Materials. (M S E 560) (2-2) Cr. 3. F. *Prereq: E Sci 351.* Property-material comparisons of metals and biomaterials emphasizing microstructural-microchemical findings as demonstrated by scanning electron microscopy and scanning transmission electron microscopy. Characterization by scanning electron microscope and energy-dispersive X-ray microchemical analysis.

564. Fracture and Fatigue. (M S E 564, M E 564) (3-0) Cr. 3. F. *Prereq: 324 and any of 337, E Sci 352, M S E 231, 270 or 271.* Materials and mechanics approach to fracture and fatigue. Fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics. Fracture and fatigue tests, thermal fracture, mechanics, and materials designed to avoid fracture or fatigue.

568. Plasticity and Creep of Materials. (M S E 568) (3-0) Cr. 3. Alt. F. offered 1981. *Prereq: 324.* Mechanics and materials approach to plasticity and creep in materials and ceramics. Yield criteria, flow rules, slip-line theory, dislocation dynamics, work hardening and metal forming processes. Introduction to creep mechanisms, stress-rupture, engineering application of creep data.

569. Mechanics of Composite and Combined Materials. (M S E 569) (3-0) Cr. 3. Alt. S. offered 1983. *Prereq: 514.* Mechanics of fibrous and laminated composites and of combined materials such as multilayered thick-walled cylinders. Macromechanical and micromechanical behavior of lamina and laminates. Strength, stiffness and interlaminar stresses of laminates. Fracture mechanics applied to composite materials.

571, 572. Advanced Fluid Mechanics. (M E 571, 572) 571: (3-0) Cr. 3. F.; 572: (3-0) Cr. 3. S. *Prereq: 571: 378 or M E 335; 572: 571.* Fundamental relationships of fluid dynamics; real and ideal fluids; laminar and turbulent flow; flow in closed conduits and open channels; boundary layer theory; two- and three-dimensional potential flow problems, engineering applications. 572: Application of complex variables to two-dimensional fluid flow; flow around solid bodies; free streamline theory. Exact and approximate solutions to Navier-Stokes equations for one- and two-dimensional laminar flow problems, both steady and unsteady flows; exact and approximate solutions to one- and two-dimensional boundary layers; introduction to turbulent boundary layers. Application to engineering problems.

580. Biomaterials. (B M E 580; M S E 580) (3-0) Cr. 3. S. *Prereq: permission of instructor.* Basic chemical and physical properties of biomaterials related to manipulation by the engineer for incorporation into living systems. Role of microstructure properties in the choice of biomaterials and design of artificial organs, implants, and prostheses.

590. Special Topics. Cr. 1 to 4 each time taken.
A. Advanced Engineering Acoustics
B. Linear Wave Propagation
C. Thermal Stresses in Design
D. Linear Viscoelasticity
E. Biomechanics
F. Other Topics

Courses for Graduate Students, major or minor

620. Seminar.(1-0) Cr. 1.

630. Continuum Mechanics. (3-0) Cr. 3. Alt. F. offered 1982. *Prereq: Math 385.* Cartesian tensors, kinematics, equations of balance, discontinuity surfaces, constitutive equations: classical elasticity, Navier-Stokes equations and simple rheological models for viscoelastic solids and fluids.

645. Advanced Vibration Analysis. (3-0) Cr. 3. Alt. F. offered 1982. *Prereq: 544, Math 385.* Nonlinear vibration phenomena. Multiple degrees of freedom, inertia and stiffness matrices, transfer matrices, numerical methods. Vibration of continuous systems, limitations, and comparison of lumped approximations of continous systems. Engineering applications.

648. Advanced Topics in Dynamics. (3-0) Cr. 3. Alt. S. offered 1983. *Prereq: 548, Math 385.* Topics of current interest in dynamics such as vehicle stability, modeling multicomponent dynamical systems and nonrigid body dynamics.

650. Fluid Mechanics Seminar. (M E 650, Aer E 650) (1-0) Cr. 1 each time taken. *Prereq: Permission of instructor.* Special topics of current research interest to students and staff of departments concerned.

651. Advanced Topics in Fluid Mechanics. (M E 651) (3-0) Cr. 3. S. *Prereq: 572.* Topics of current interest in fluid mechanics such as separation phenomena, three-dimensional boundary layers, unsteady flow phenomena, asymptotic methods in viscous flows, stability, theory of homogeneous isotropic turbulence, and turbulence models.

684, 685. Similitude in Engineering. (2-2) Cr. 3 each. Yr. *Prereq: 324, permission of instructor.* Principles of dimensional analysis and their application to design of models. Design, testing, and interpretation of models. True and distorted models, linear and nonlinear models, analogies. Applications.

690. Special Topics, Credit 1 to 6 each time taken.
A. Advanced Experimental Mechanics
B. Nonlinear Wave Propagation
C. Nonlinear Material Behavior
D. Composite Materials
E. Holography in Mechanics
F. Finite Elements of Nonlinear Continua
G. Fracture Mechanics
H. Atmospheric Fluid Mechanics
I. Viscous Flow Theory
J. Advanced Similitude Analysis
K. Advanced Analytic Methods in Mechanics
L. Rheology
M. Creative Component
N. Other Topics

699. Research.

Engineering Science

Administered by the Department of Engineering Science and Mechanics

Harry J. Weiss, Head of Department

Minor work is available to students taking major work in other departments.

Courses for Graduate Students, minor only

351. Engineering Materials. (M S E 351) (3-2) Cr. 4. F. *Prereq: Credit or classification in E M 324.* Resistance of materials to failure, definitions and evaluation of properties, relationship to design. Effects of environment on properties. Laboratory determinations. Structure of materials, and influence of structure upon properties.

352. Engineering Materials. (M S E 352) (3-2) Cr. 4. S. *Prereq: 351.* Thermal, magnetic, and electrical characteristics, properties of single crystals, poly-crystalline systems, aggregates of domains. Interatomic forces, energy considerations. Engineering applications.

380. Basic Engineering Design II. (2-2) Cr. 3. S. *Prereq: 280.* Design of experiments to measure basic parameters, interpretation of experimental data and empirical relationships.

412. Energy Sources and Utilization. (3-0) Cr. 3. S. *Prereq: M E 331, E M 378 or M E 335.* Sources of energy, methods of utilization and transformation. Over-all design of energy systems.

481, 482. Advanced Analysis and Design. (3-0) Cr. 3 each. Yr. *Prereq: 481: 380, a fluids course, 482: 481.* Application of the engineering sciences to the analysis and design of components and systems.

490. Independent Study. Cr. 2 to 5. *Prereq: Permission of department head.* Investigation of an approved problem commensurate with the training, interest, and ability of the student.
H. Honors.

English

Frank E. Haggard, Chair of Department

The Graduate Faculty

Members: Benson, Bruner, Consigny, P. G. Davies, Leonard Feinberg, Herrnstadt, Huntress (Emeritus), Jumper, Nakadate, Poague, Silet, Walker (Emeritus), Yates

Associate Members: Anderson, G. Bataille, R. R. Bataille, Cummings, Flick, Fowler, A. E. Galyon, L. R. Galyon, Gonzo, Gwiasda, Haggard, Johnson, Kroll, J. A. Lowrie, Mallam (Emeritus), McCarthy, Nostwich, Palmer, Ross, Speer, Zbaracki, Zimmerman

The department offers work for the Master of Arts degree with a major in English, and minor work for students majoring in other departments. The master's degree requires 30 semester credits, including a thesis (3 credits) or a major project (ordinarily 3 credits). Courses must include 530, 511 or 512, and usually 503. Basic knowledge of one foreign language must be demonstrated by test or course work. Toward the end of the program, each candidate writes an examination covering a major author and a period or area in literature, linguistics, or other programs offered by the department agreed on by the candidate and the examination committee. Candidates admitted to major graduate work should have completed undergraduate study substantially equivalent to that in the undergraduate program in English at Iowa State.

Individual graduate programs of study are designed to prepare students for (1) teaching at the secondary, two-year college, or beginning college and university levels, (2) further graduate study in language and literature, (3) teaching English as a second language, (4) creative writing, (5) technical writing, editing, and associated commercial writing activities.

The department participates in the interdepartmental program in Technology and Social Change (see Index) and provides practicum or similar experiences for English graduate students in the Writing Center, Reading Center, Intensive English and Orientation Program, Freshman English Program, and selected departmental research activities. Some financial assistance awards for graduate students are available.

Graduate students in English may include 495 in their major programs of study. Selected courses in English may be used to meet part of the requirements for certification to teach English in two-year and community colleges (see department information bulletin).

Courses for Graduate Student, minor only

315. Creative Writing — Screenplays. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 105, not open to freshmen.* Stresses master scene technique of writing fully developed screenplays. Course may be repeated in conjunction with actual production of film or teleplay. Emphasis on TV and movie techniques, writing, workshop criticism, analytical reading and viewing, and individual conferences.

316. Creative Writing — Playwriting. (Sp 316) (3-0) Cr. 3. *Prereq: 105, not open to freshmen.* Progresses from production of scenes to fully developed one-act plays. Emphasis on action, staging, writing, analytical reading, workshop criticism, and individual conferences.

335. Film. (3-0) Cr. 3. F.S. *Prereq: 105.* Principles of film art and the traditional vocabulary of literature as applied to film. Influence of film on modes of thought and behavior. Fee.

345. Literature by or About Women. (W.S. 345) (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 105.* Literature by women and/or dealing with the images of women.

346. American Indian Literature. (Am In 346) (3-0) Cr. 3. Alt. Yr. *Prereq: 105.* Survey of literature of the American Indian from pre-Columbian tales and songs to contemporary novels and poetry.

347. Survey of Black American Literature. (3-0) Cr. 3. S. *Prereq: 105.* Literature by Black Americans from the beginnings to the 1960's.

349. Selected Topics in Minority Literatures. (3-0) Cr. 3 each time taken, maximum of 6. F. *Prereq: 105.* Literature by and/or about American ethnic minorities. May include literature of several ethnic groups or focus upon one of the following: Asian Americans, Black Americans, Hispanic Americans, American Indians.

357. Folk Literature and Myth. (3-0) Cr. 3. Alt. Yr. *Prereq: 105.* Folk literature, its types and functions, in both sacred and secular traditions. Emphasis on traditional narratives (epic, legend, ballad, folk and fairy tale), myth, proverbs, and riddles.

366. Studies in Drama. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 105.* Selected topics in the study of drama. Examination of important themes, genres, dramatists, and periods.

394. Literature of Adolescence. (3-0) Cr. 3. *Prereq: 105.* Literature for and about the adolescent. Critical study and evaluation of the genre; examination of modes and themes found in the literature; study of the relationship of the genre to literature for children and adults. Selection of literature for use in school programs.

400. Studies in Film. (Sp 400) (4-0) Cr. 2 to 4 each time taken, maximum of 6. *Prereq: One 3-credit course in film, junior classification.* Approaches to film; analysis of individual film styles, themes, genres, directors; esthetic and cultural significance of fiction and nonfiction films. Fee.

414. Writing of Professional Papers and Reports. (3-0) Cr. 3. F.S.SS. *Prereq: 105, junior classification.* Writing of business, technical, or research papers and reports, including a major analytical report, on topics from the student's discipline.

420. History and Dialects of the English Language. (3-0) Cr. 3. *Prereq: 105, junior classification.* Background and development of the English language. Relationships of English to other languages of the past and present. Linguistic change, current developments in English vocabulary, structure. The regional and social dialects of American English.

495. Teaching English to Speakers of Other Languages: Methods and Materials. (3-0) Cr. 3. *Prereq: 219 or an introductory course in linguistics.* Teaching grammar, reading, writing, listening comprehension, speaking, and pronunciation. Testing and evaluation. Open to graduate students in English for major graduate credit.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

503. Teaching Composition: Approaches to Writing and Rhetoric. (3-0) Cr. 3 or 4. *Prereq: Undergraduate major or certification to teach English.* Current practices and problems in teaching composition at the secondary, junior college, and college levels. Preparation of assignments, evaluation of papers, syntactic and rhetorical analysis, theories of the composing process with applications.

504. Advanced Imaginative Writing. Cr. 1 to 3 each time taken, maximum of 9. *Prereq: 404 and submission of portfolio to instructor well before the course begins.* Individual projects on a workshop and conference basis.

505. Theory and Pedagogy of Reading. (3-0) Cr. 3. *Prereq: 3 credits in linguistics, psycholinguistics, or language acquisition.* Theoretical models and research developments in reading. Practice with standardized, informal, and diagnostic instruments for measurement of reading. Implications for teaching reading in secondary schools.

507. Professional and Occupational Writing. (3-0) Cr. 3. *Prereq: 302 or 414.* Writing and analysis of documents prepared in business, science, and industry: reports, manuals, instructions, etc. Individual projects directed to improving writing skill or to training in editing and teaching. Guided readings.

511. Introduction to General Linguistics. (3-0) Cr. 3. F., Alt. SS. *Prereq: 3 credits in linguistics.* Principles of general linguistics; history of the development of modern linguistic science.

512. Historical Linguistics and Language Classification. (3-0) Cr. 3. S., Alt. SS. *Prereq: 3 credits in linguistics or in British literature before 1600.* English historical linguistics. Genealogical and typological classification of languages.

514. Regional and Social Dialects of American English. (3-0) Cr. 3. *Prereq: 3 credits in linguistics.* English at the time of early settlement, non-English influences, American dialect geography; Black English; social variation in present-day American English, pedagogical implications.

515. Phonology. (3-0) Cr. 3. *Prereq: 511 or an introductory course in linguistics.* Theoretical and practical analysis of the sound systems of languages, with an emphasis on English phonology.

516. (419 DL) English Syntax. (3-0) Cr. 3. *Prereq: 3 credits in linguistics.* Graduate study in conjunction with English 419. May not be taken by students who have previously earned credit in English 419. Additional readings, term project, and special examination for students who enroll for 516.

517. Theoretical Foundations for Teaching English to Speakers of Other Languages. (3-0) Cr. 3. *Prereq: 511 or an introductory linguistics course.* Theoretical issues and research in second language acquisition: related developments in theoretical linguistics, psycholinguistics, and language pedagogy. (For TESOL methods course, see 495).

521. Teaching Literature and the Literature Curriculum. (3-0) Cr. 3. *Prereq: 9 credits in literature.* Examination of the roles of the literary work, reader, and teacher in literary study. Responses to literature. Place of literature in language arts. Study and development of curriculum materials for varied levels of instruction.

522. Literary Criticism. (3-0) Cr. 3. *Prereq: 9 credits in literature.* Introduction to the major approaches to literature.

530. Research and Bibliography. (3-0) Cr. 3. F., Alt. SS. *Prereq: 12 credits in English.* Required of candidates for the M.A. degree in English.

532. Satire. (3-0) Cr. 3. *Prereq: 6 credits in literature.* Selected major texts of satire in the Anglo-American tradition. Study of the major critical theories of the genre.

534. Science and Literary Imagination. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 6 credits in literature.* Literature and science considered as complementary expressions of basic cultural paradigms. Close attention to imagery, metaphor, and theories of literary language. Alternate offerings emphasize Newtonian (17th-19th centuries) and modern (19th-20th centuries) periods.

546, 547, 548. Twentieth Century Literature. (3-0) Cr. 3 each time taken, maximum of 6 each. *Prereq: 6 credits in literature.* 546: Selected poets, studied singly or in combination. 547: Selected writers of fiction, studied singly or in combination. 548: Selected dramatists, studied singly or in combination.

563. American Fiction to 1900. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 6 credits in American literature.* Selected writers in combination, such as Hawthorne and Poe, Twain and Howells, Melville and James.

564. Significant American Nonfiction. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 6 cr. in American literature.* Material studied alternates between transcendentalism as a force in American literature, and trends in American nonfiction since 1840.

566. American Poetry to 1900. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 6 credits in American literature, including 361.* Selected poets in combination.

570. Renaissance English Literature. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 6 credits in English literature, 374 recommended.* Studies of non-dramatic literature of the 16th and early 17th centuries, alternating between emphasis on the early Renaissance and on the later Renaissance.

571. Restoration and 18th Century British Literature. (3-0) Cr. 3. *Prereq: 6 credits in English literature, preferably 374, 375.* Selected poetry and prose.

572. British Drama to 1714. (3-0) Cr. 3 each time taken, maximum 6. *Prereq: 6 credits in literature, preferably 373, 374.* Studies of selected non-Shakespearean dramas, alternating between emphasis on the earlier and on the later parts of the period.

574. Chaucer. (3-0) Cr. 3. *Prereq: 6 credits, 373 recommended.* Intensive study of selected *Canterbury Tales* and minor poems. Introduction to Chaucer scholarship.

575. Milton. (3-0) Cr. 3. *Prereq: 6 credits, 374 recommended. Paradise Lost,* with other selections from the poetry and prose. Introduction to Milton scholarship.

576. Nineteenth Century British Literature. (3-0) Cr. 3 each time taken, maximum of 6. *Prereq: 6 credits in English literature, 376 or 377 recommended.* Studies of selected poets and prose writers of the 19th century, usually alternating between emphasis on the Romantic period and emphasis on the Victorian period.

580. Shakespeare. (3-0) Cr. 3. *Prereq: 6 credits in English literature prior to 1800.* Shakespeare as poet and dramatist. Chief critical schools and areas of scholarship.

582. (391 DL) The English Novel to 1832. (3-0) Cr. 3. *Prereq: 6 credits in English literature.* Graduate study in conjunction with English 391. Additional readings, project, and special examination for students who enroll for 582. May not be taken by students who have previously earned credit in English 391.

583. (392 DL) The Victorian Novel. (3-0) Cr. 3. *Prereq: 6 credits in English literature.* Graduate study in conjunction wtih English 392. Additional readings, project, and special examination for students who enroll for 583. May not be taken by students who have previously earned credit in English 392.

589. Seminar. Cr. var. *Prereq: 12 credits in literature, linguistics, or rhetoric (excluding 104-105).*
A. Literature; Criticism
B. Linguistics
C. Rhetoric; Composition
D. Pedagogy

590. Special Topics. Cr. var. *Prereq: Permission of the department executive officer, according to guidelines available in the department office.*
A. Literature; Criticism
B. Linguistics
C. Rhetoric; Composition
D. Pedagogy

699. Research.

Entomology

Paul A. Dahm, Chair of Department

The Graduate Faculty

Members: Brindley, Coats, Dahm, Guthrie, Hart, Jarvis, Krafsur, L. C. Lewis, R. E. Lewis, Mertins, Mutchmor, Pedigo, Rowley, Showers

Associate Members: DeWitt, Stockdale, Tollefson

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in entomology. Within the major, the student may specialize in behavior, biological control, ecology, economic entomology, host plant resistance, medical entomology, morphology, pathology, pest management, physiology, systematics, or insecticide toxicology.

Prerequisite to major and minor graduate work in the department is completion of at least two years of zoological courses, for part of which credit in other closely allied biological sciences may be substituted. Specific course requirements for advanced degrees depend partly upon previous training and experience in the major field of specialization.

Any student receiving a graduate degree in entomology shall have one course in at least three of the following areas for the M.S. degree and one course in each of the following areas for the Ph.D. degree: insect morphology, systematic entomology, insect physiology, and insect ecology. Equivalents of these courses taken at other universities will be acceptable.

The Federal Corn Insects Research Unit at Ankeny is available for advanced study in certain phases of entomological research.

The department participates in the interdepartmental programs of Immunobiology and Molecular, Cellular and Developmental Biology (see Index).

Courses for Graduate Students, minor only

370. General Entomology. (2-3) Cr. 3. F.S. *Prereq: Zool 206, 206L.* Hart, Krafsur. Structure, physiology, evolution, behavior, life histories, and recognition of insects. Voluntary field trips.

376. Fundamentals of Entomology and Pest Management. (P M 376) (2-3) Cr. 3. S. *Prereq: Biol 110.* Coats, Pedigo. Introduction to entomology and insect-pest management, including biology, ecology, economics, and tactics of population suppression.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Seminar. Cr. 1. F.S. *Prereq: Permission of instructor.* Reports of research and current literature.

544. Advanced Forest Pest Management. (PP SW 544) See *Plant Pathology, Seed and Weed Sciences.*

570. Host Plant Resistance to Insects. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 370 or 376.* Tollefson. Principles and mechanisms of insect control by host plant resistance.

572. Insect Morphology. (2-6) Cr. 4. F. *Prereq: 15 credits in zoological sciences, including 370.* Hart. Intensive study of the functional anatomy of insects.

573. Economic Entomology. (3-3) Cr. 4. F. *Prereq: 370.* Tollefson. Contemporary concepts of insect biology and insect population management.

574. Medical Entomology. (2-6) Cr. 4. F. *Prereq: 9 credits in biological sciences.* Rowley. Identification, biology, and significance of insects and other arthropods that attack people and animals, particularly those that are vectors of disease. Field trips.

575. Biological Control. (3-0) or (3-3) Cr. 3 or 4. Alt. F, offered 1981. *Prereq: 370, permission of instructor.* Mertins. Theory and practice of biological control of insects and other pests; biology and behavior of entomophagous insects, entomogenous nematodes, and pathogenic microorganisms; review and critique of important world projects.

576. Systematic Entomology. (3-6) Cr. 5. S. *Prereq: 370.* Classification, distribution and natural history of insects including fundamentals of nomenclature and taxonomic practice. Field trips when practical.

577. Immature Insects. (2-6) Cr. 4. Alt. F, offered 1982. *Prereq: 576.* Lewis. Taxonomy, distribution and natural history of immature insects including techniques of collection and preservation. Field trips when practical.

590. Special Topics. Cr. 1 to 3 each time taken. *Prereq: 15 credits in zoological sciences, permission of instructor.*
E. Special research topics.
T. Internship experience in the techniques of organizing and disseminating applied entomological information.
U. Teaching experience.

Courses for Graduate Students, major or minor

655. Insect Physiology. (Zool 655) (3-6) Cr. 5. S. *Prereq: 370; Zool 355.* Mutchmor. Life processes of the insects, including reviews of current problems in insect physiology.

671. Insect Ecology and Pest Management. (2-3) Cr. 3. Alt. S., offered 1983. *Prereq: 370, Biol 309, Stat 401.* Pedigo. Concepts of insect population dynamics, emphasizing sampling, outbreaks, analysis, bioeconomics, and management systems.

674. Advanced Medical Entomology. (1-6) Cr. 3. Alt. S., offered 1982. *Prereq: 574.* Rowley. Vector-parasite relationships, ecology, and epidemiology of arthropod-borne animal diseases.

675. Insecticide Toxicology. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 572, 655.* Coats, Dahm. Principles of insecticide toxicology; classification, mode of action, metabolism, and environmental effects of insecticides.

699. Research.

Environmental Studies

(Interdepartmental Undergraduate Program)

Craig B. Davis, Coordinator

Courses for Graduate Students, minor only

421. Policies and Procedures in Environmental Analysis. (U St 421) (2-2) Cr. 3. F. *Prereq: 221, 222.* History of environmental legislation and the development of environmental assessment. Interrelationships among federal, state, and local agencies; the public and the courts in implementing environmental laws and regulations. Techniques for the analysis and preparation of environmental impact statements under the National Environmental Policy Act. Field trips.

425. Environment and Society. (U St 425) (3-0) Cr. 3. SS. *Prereq: 10 hours in social or natural sciences.* An in-depth analysis of natural and human-modified ecosystems with attention on energy, resources, food, and population as they relate to society and the quality of human environments.

Family Environment

Edward A. Powers, Chair of Department

The Graduate Faculty

Members: Bivens, Deacon, Liston (Emeritus), Morris, Peet, Powers, Winter

Associate Members: Budolfson (Emeritus), Cole, Heltsley, Jeries, Mercier, Norem, Pickett, Schwieder, Weltha

The department offers the degree of Master of Science with a major in family environment, and the Ph.D. degree as a joint major with another field such as chemistry, child development, economics, education, food and nutrition, home economics education, physics, sociology, and anthropology. A family environment minor is available for Ph.D. students majoring in other departments.

The department cooperates in the interdepartmental programs of Housing, Gerontology, Technology and Social Change, and Water Resources (see Index).

Prerequisite to major work in family environment is the completion of at least 10 credits in each of the following areas: communicative arts, humanities, physical and biological sciences, and social and behavioral sciences. The student should also have the equivalent of the courses generally considered as introductory principles in the family environment program at this institution. Educational background in the physical and/or social sciences may be suitable, depending on the student's objectives.

Guidelines for graduate programs of study in family environment have been developed. However, the student's program of study committee has the major responsibility for determining requirements for an individual program.

Courses for Graduate Students, minor only

408. Care of Modern Fabrics. (3-0) Cr. 3. S. *Prereq: 3 credits in textiles or household equipment.* Application of basic physical and chemical principles to effective clothing care. Analysis of appliance design, materials, and procedures for fabric care. Emphasis on resource conservation. Review of research and current literature.

410. Food-Related Major Home Appliances. (2-4) Cr. 3. F. *Prereq: 354, laboratory in Chem, F N or Phys.* Design and performance of freezers, microwave ovens, ranges, and refrigerators. Use and evaluation in terms of utility to consumer.

412. Kitchen, Bath, and Utility Area Planning. (2-2) Cr. 3. S. *Prereq: 6 credits in housing, art and design, or architecture.* Criteria for planning of kitchen, bath, utility areas. Application of human engineering principles for effective functioning in work areas. Emphasis on economy, resource conservation, and space adaptation.

415. Families as Consumers. (3-0) Cr. 3. F.S. *Prereq: 3 credits in psychology, 3 credits in sociology, Econ 201.* Theories of consumer behavior; the family's relationship to the consumer movement; consumer issues; dimensions of consumer role; interaction of consumers; government and the market; consumer decision making; evaluation of information and protection.

446. Housing Alternatives for Individuals and Families. (2-4) Cr. 3. F. *Prereq: 240.* Meeting human needs at various stages of the life cycle through alternative housing forms. Emphasis on internal housing environment as influenced by social, technological, and physical factors. Field trip. Fee.

471. Family Analysis and Planned Change. (2-1) Cr. 3. S. *Prereq: 378, 391.* Application of theory and methods to the analysis of individual and family problems. Integration of problem-solving approaches.

479. Family Interaction Dynamics. (3-0) Cr. 3. F. *Prereq: 370, 378.* Analysis of family interaction processes and patterns with emphasis on relationship dynamics.

488. Family Financial Management. (2-2) Cr. 3. F.S. *Prereq: 201 or 3 credits in psychology, 3 credits in sociology, Econ 201.* Family financial management as affected by interrelationships between society and families. Decision making relative to acquiring and allocating income. Financial management focused on borrowing, taxes, housing, insurance, savings, investments, retirement, and estate planning.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

500. Short Course. Cr. arr. Designed primarily for special groups. Not accepted for graduate credit in family environment.
A. Family Relations and Management
B. Housing
C. Consumer Economics and Management
D. Household Equipment
G. General Family Environment

501. Graduate Study Orientation. (1-0) Cr. 1. F. Orientation to graduate study and current research in the department.

504. Research Methods and Techniques. (3-0) Cr. 3. S. *Prereq: 9 credits in social sciences.* Research methods and techniques applicable to studies of families and households. Emphasis on the solution of practical problems of analysis using SPSS, WYLBUR, and other programs.

510. Technological Development and the Environment of the Family. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 3 credits of 500-level courses in family environment.* Technology as a force influencing and influenced by individual and family needs. Implications of technological change on life styles. Intensive analysis of technological concepts, assumptions, and interpretations.

519. Consumer Dynamics. (3-0) Cr. 3. Alt. S, offered 1983. *Prereq: 415, 488; Econ 401.* Consumer roles in the evolution of economic society. Analysis of consumer interactions with public and private institutions serving consumer interests. Emphasis on process of consumer decision making.

521. Housing and the Social Environment. (3-0) Cr. 3. F. *Prereq: 504 and 6 credits in sociology.* Housing adjustment behavior of individuals and families in the context of the social and cultural framework of society. Impact of housing on the family.

522. Time and Human Resources. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: Econ 401.* Conditions, programs, and policies related to development and allocation of human resources and time, with special reference to impact on families and households.

523. Management within the Family. (3-0) Cr. 3. F. *Prereq: 378, 6 credits in sociology or economics.* Theoretical developments and research related to the use of family resources to achieve family goals. Emphasis on systems theory as applied to family management.

540. Energy in the Residential Environment. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 9 credits in social and/or physical sciences.* Factors affecting availability and use of energy in the home.

565. Pragmatics of Family Communication. (3-0) Cr. 3. F. *Prereq: 6 credits in behavioral sciences.* Influence of communication including language and cultural aspects in family relationships. Emphasis on functional interpersonal communication in maintenance of holistic health of family members.

570. The Individual and Family Development. (3-0) Cr. 3. S. *Prereq: 9 credits in behavioral sciences.* Experiential learning and encounter with contemporary theories of human potential in individual and family living.

575. Cultural Foundations of Family Life. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 378.* Cultural influences in individual and family development. Comparison of family roles, values, customs, taboos, and rituals in contrasting cultures.

577. Aging and Intergenerational Relations. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 378, Psych 230, Soc 305.* Personal and family adjustments to role changes in later life that affect older persons and their adult children.

578. Family Theory. (3-0) Cr. 3. S. *Prereq: 12 credits in behavioral sciences.* Analysis of conceptual frameworks in the area of the family by examining their development, concepts, assumptions, inadequacies, and contradictions.

579. Family Dynamics. (3-0) Cr. 3. F. *Prereq: 479 or Soc 485.* A psychosocial analysis of intrafamilial interaction processes and patterns with an emphasis upon relationship issues such as emergent roles and power.

580. The Family and the Law. (3-0) Cr. 3. SS. *Prereq: 415 or 488 or Mgmt 315.* Examination of the effects of selected legislation and cases on individuals and families. Discussion of the legal processes involved in the activities of individuals and families. Implications for effective functioning within the limits of the legal environment. Investigation of legal and quasi-legal services available in a community.

588. Family Economics. (3-0) Cr. 3. F. *Prereq: 415, 488.* Problems of measuring family income, wealth, and welfare. Programs for improving adequacy and security of income during family life cycle. Factors which influence standards and levels of living.

590. Special Topics. Cr. arr. *Prereq: Permission of instructor.* Consult department office on procedure for filing a written plan of study.
A. Family Relations and Human Development
B. Housing
C. Consumer Economics and Management
D. Household Equipment
F. Field Trips and Field Experience
G. General Family Environment

591. Practicum in Family Environment. (as arr.) Cr. 1 to 6 each time elected. *Prereq: 10 graduate credits. Supervised experience in the following areas of family environment.*
A. Family Relations and Human Development
B. Housing
C. Consumer Economics and Management
D. Household Equipment
G. General Family Environment

Courses for Graduate Students, major or minor

604. Seminar. Cr. 1 to 3. F.S.
A. Family Relations and Human Development
B. Housing
C. Consumer Economics and Management
D. Household Equipment
G. General Family Environment

676. Family Therapy. (3-0) Cr. 3. Alt. F., offered 1981 *Prereq: 565, 578.* Application of family and counseling theory to the process of therapeutic intervention with families. Emphasis on systems dynamics orientation.

699. Research. Cr. arr.
A. Family Relations and Human Development
B. Housing
C. Consumer Economics and Management
D. Household Equipment
G. General Family Environment

Fisheries and Wildlife Biology

For description of courses, see *Animal Ecology*.

Food and Nutrition

Jacqueline Dupont, Chair of Department

The Graduate Faculty

Members: Brewer, Dupont, Garcia, Hathcock, Osman

Associate Members: Chen, J. Love, M. Love, T. Runyan, W. Runyan, Serfass, Sizer

The department offers work for the degree Master of Science with majors in food science, nutrition, and food and nutrition, and for the degree Doctor of Philosophy with majors in food science and nutrition, and minor work for students taking major work in other departments.

Prerequisite to major work is the completion of a curriculum in food and nutrition substantially equivalent to that required of undergraduates at Iowa State University. Students with undergraduate majors in biological and physical sciences also are qualified for graduate study in food science and nutrition.

Students taking major work for the degree Doctor of Philosophy either in food science or in nutrition may choose minors from other fields of home economics as well as from anthropology, chemistry, biochemistry, bacteriology, economics, education, food technology, journalism, psychology, physiology, sociology, statistics, or other related fields.

For the degree Doctor of Philosophy, there is a requirement for (1) demonstration of a satisfactory reading knowledge of two foreign languages or (2) competence in communication in one foreign language as demonstrated by examination or as indicated by two years of course work (C grade or better) in the baccalaureate program. The program of study committee may substitute evidence of a high level of competence in a subject matter area of skill outside the major or minor (such as DVM or MD degree, certification in a technical speciality, skill in an advanced instrumental or computational technology) for the foreign language requirement. The substitution must contribute to doctoral performance and must be approved by the departmental executive officer.

Courses for Graduate Students, minor only

305. Nutrition and Dietetics. (3-0) Cr. 3. F.S. *Prereq: 3 credits in biochemistry and 3 credits in physiology.* Physiological and chemical bases for nutrient needs; factors to consider in satisfying those needs for individuals and populations.

305L. Nutrition and Dietetics Laboratory. (0-3 or 6) Cr. 1 or 2. F.S. *Prereq: Credit or classification in 305.* Laboratory experiences in dietary analysis, metabolic balance, and nutritional status assessment.

410. Nutrition in Growth and Development. (4-0) Cr. 4. F.S. *Prereq: 305.* Nutrition during human growth and development with emphasis on interrelations of nutrition and biological functions.

413. Community Nutrition. (2-3) Cr. 3. F.S. *Prereq: 305.* Survey of current public health nutrition problems among nutritionally vulnerable individuals and groups; discussion of the multidimensional nature of those problems and of community programs designed to help solve them and the role of community nutritionists. Concurrent field observations. Fee.

414. Program Development in Community Nutrition. (2-3) Cr. 3. S. *Prereq: 413.* Identification of problems; introduction to planning and evaluation of programs. Dietary surveys of small population groups are designed and conducted with faculty guidance. Fee.

431. Nutrition in Disease. (3 or 4-0) Cr. 3 or 4. F.S. *Prereq: 305.* Pathophysiology of selected medical problems with specific attention to nutritional needs and treatment as part of medical therapy.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Short Course. Cr. arr. SS. *Prereq: Permission of instructor.*

510. Malnutrition in Developing Countries. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 305 or An S 318.* Identification and quantitative assessment of malnutrition in developing countries; social, political, economic, and geographic ecology of malnutrition and its impact on health; protein-calorie malnutrition; vitamin and mineral deficiencies; intervention organizations, programs, and efforts.

520. Current Topics in Food Science. (2-0) Cr. 2. S. *Prereq: 421; B B 404.* Research literature in selected areas of food science.

550. Processed Foods. (3-0) Cr. 3. S. *Prereq: 214; 305.* Survey of the effects of home and commercial food preparation and processing on the nutrients in food.

590. Special Topics. Cr. arr. *Prereq: 305; permission of departmental executive officer and instructor.*
A. Nutrition
B. Food Science
C. Professional Problems

Courses for Graduate Students, major or minor

601. Advanced Nutrition. (4-0) Cr. 4. S. *Prereq: 305; B B 404 and credit or classification in B B 405.* Principles of human nutrition: Nutrition for energy, body structure and function; nutritional interrelationships; nutrient requirements, status assessment, and availability; nutritional diseases; socio-cultural influences on nutrition.

606. Chemical Methods for Research in Food and Nutrition. (1-6) Cr. 3. F. *Prereq: 305; Chem 211 or equivalent.* Application of chemical techniques to research in nutrition and food science.

607. Animal Experimentation in Nutrition Research. (1-0 or 6) Cr. 1 or 3. S. *Prereq: 606 or 305 and Chem 211. The animal feeding experiment as a technique in nutrition research. Principles and basic experimental design using small laboratory animals. Individual problems in the laboratory animal.*

609. Seminar. (1-0) Cr. 1. F.S. Required of all graduate majors in the Food and Nutrition Department.

612. Food Lipids. (F Tch 612) (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 421 or F Tch 411 or B B 404.* Structure and analysis of food lipids, glyceride structure, crystal form and texture, autoxidation, refining and processing of fats and oils.

613. Food Proteins. (F Tch 613) (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 421 or F Tch 411 or B B 404.* Properties of proteins found in milk, eggs, meat, and cereal grains. Effect of processing on food proteins.

614. Carbohydrates in Foods. (F Tch 614) (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 421 or F Tch 411 or B B 404.* Study of production of carbohydrates used in foods, changes they undergo during processing and storage of food, and relation of their functions to their chemical and physical properties.

615. Selected Topics in Nutrition. (2-0) Cr. 2 each time selected. F. *Prereq: 601.* Series of one-term courses on such topics as protein, vitamins, minerals, lipids, energy metabolism, evaluation of nutritional status. Classical and current research literature in each area.

619. Research Methods in Food Science. (1-6) Cr. 3. F. *Prereq: 421; Chem 332; Micro 420.* Application of physical, chemical, and organoleptic techniques to research in food science. Use of experimental design, analysis of data, and review of literature.

630. Nutritional Pharmacology and Toxicology. (3-0) Cr. 3. F. *Prereq: 601.* Mechanistic and biometric concepts; nutrient toxicities and imbalances; diet-drug incompatibilities; nutritional effects on drug metabolism and cancer etiology; toxicants in the food chain; regulatory policy and philosophy.

680. Modern Views of Nutrition. (An S 680) See *Animal Science.*

699. Research.
A. Nutrition
B. Food Science

Food Technology

W. W. Marion, Head of Department

The Graduate Faculty

Members: Glatz, Hammond, Hartman, Kline, Kraft, Marion, Nielsen, Parrish, Robson, Stromer, Walker

Associate Members: Love, Murphy, Olson, Rust, Sebranek, Wilson

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in food technology, and minor work for students majoring in other departments. Graduate work in meat science is offered as a co-major in animal science and food technology.

The department also participates in the interdepartmental programs of Molecular, Cellular, and Developmental Biology, and Water Resources. (See *Index.)*

Prerequisite to major graduate work is the satisfactory completion of an undergraduate curriculum essentially equivalent to the food technology curriculum offered in this department or the completion of a curriculum in a related science such as dairy technology, bacteriology, chemistry, biochemistry, or engineering. Preparation in biology, chemistry, physics, and calculus along with knowledge of food processing, sanitation, and preservation are particularly desirable for those intending to pursue graduate work.

Courses for Graduate Students, minor only*

301. Processing of Dairy Products. (2-3) Cr. 3. S. *Prereq: 101.* Procedures used in making, distributing, and controlling the quality of dairy products. Fee for field trips.

302. Processing of Fruits and Vegetables. (2-3) Cr. 3. F. *Prereq: 101 or Hort 371.* Harvesting, handling, processing, and storage of fruits and vegetables. Current practices and problems. Flavor, color, composition, nutritional value and safety of raw and processed fruits and vegetables. Fee for field trip.

360. Seminar on Contemporary Problems in Food Technology. (1-0) Cr. 1. F. *Prereq: 101.*

401. Food Processing. (Micro 401) (3-0) Cr. 3. F. *Prereq: 101, Micro 300.* Food preservation, packaging, and quality changes. Food fermentations.

402. Food Processing Laboratory. (Micro 402) (0-6) Cr. 2. F. *Prereq: 102, Micro 300.* Thermal processing, low temperature preservation, packaging methods, food fermentations, use of starter cultures. Fee for field trips.

405. Food Quality Assurance. (2-0) Cr. 2. S. *Prereq: 410 or 420; Stat 104.* Use of biological, chemical and physical analyses to maintain quality and safety. Design of food quality control programs and their application to food systems.

410. Food Analysis. (1-6) Cr. 3. S. *Prereq: Chem 211; 231 or 331.* Proximate, spectrophotometric, and chromatographic methods for food analysis. Physical properties.

411. Food Chemistry. (2-3) Cr. 3. F. *Prereq: B B 301.* The structure, properties and reactions of food constituents and commodites.

421. Food Microbiology Laboratory. (Micro 421) (1-6) Cr. 3. F.S. *Prereq: Micro 300.* Standard microbiological techniques employed in the food industry, including microscopic examination of foods, sampling methods, plate counts, and other enumeration methods, indicator organisms of food quality and safety. Fee for field trips.

425. Food and Water Sanitation. (Micro 425) (3-0) Cr. 3. S. *Prereq: Micro 300.* Control methods and regulations for maintaining sanitation and quality of foods and water.

493. Engineering Principles for Food Technology I. (Ag M 493) (2-3) Cr. 3. F. *Prereq: Math 160; Phys 106 or 111 or 221.* Introduction to the principles of food process engineering. Applications of basic mechanics, electricity, fluid mechanics and heat transfer to food processing. Fee for field trips.

494. Engineering Principles of Food Technology II. (Ag M 494) (2-3) Cr. 3. S. *Prereq: 493.* Psychrometrics, air conditioning, evaporation, materials handling, drying, and process analysis.

***For graduate majors where undergraduate preparation was not in food technology or food-product technology but in a related science, 9 hours of food technology courses with 400 numbers may be taken, with approval of the student's program of study committee.**

Courses primarily for graduate students, major or minor, open to qualified undergraduates.

538. Food Industry Regulations. (2-0) Cr. 2. Alt. S. 1983. *Prereq: Permission of instructor.* International, federal, state, and local regulations affecting food product development, manufacture, and marketing; standards and definitions, food safety and consumer protection.

547. Biological Applications of Microscopy. (2-0) Cr. 2. Alt. F. Offered 1982. *Prereq: Permission of instructor.* Stromer. Principles and types of information obtained from light and electron microscopy techniques. Photomicrography and photomacrography. Demonstrations and structural data analysis with various biosystems.

Courses for Graduate Students, major or minor

611. Sensory Properties of Foods. (2-2) Cr. 3. Alt. F., offered 1982. *Prereq: 411 or B B 404.* Isolation and identification of flavors, flavor evaluation, texture and consistency of foods, color descriptions of foods.

612. Food Lipids. (F N 612). (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 411 or B B 404 or F N 421.* Structure and analysis of food lipids, glyceride structure, crystal form and texture, autoxidation, refining and processing of fats and oils.

613. Food Proteins. (F N 613). (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 411 or B B 404 or F N 421.* Properties of proteins found in milk, eggs, meat, and cereal grains. Effect of processing on food proteins.

614. Carbohydrates in Foods. (F N 614). (3-0). Cr. 3. Alt. S., offered 1983. *Prereq: 411 or B B 404 or F N 421.* Study of production of carbohydrates used in foods, changes they undergo during processing and storage of food, and relation of their function to their chemical and physical properties.

626. Advanced Food Microbiology. (Micro 626) (1-0 to 3-0) Cr. 1-3 Alt. S., offered 1982. *Prereq: Micro 420.* Topics of current interest in food microbiology, including new food-borne pathogens, rapid identification methods, effect of food properties and preservation techniques on microbial growth.

660. Seminar. (1-0) Cr. 1. F.S.SS.

690. Special Problems. Cr. arr. F.S.SS. *Prereq: A major or minor in food technology.*

699. Research.

Foreign Languages and Literatures

Orrin Frink, Chair of Department

The Graduate Faculty

Members: Bruner, Courteau, Dow, Frink, McVicker, Morris, Thogmartin

Associate Professors: Bernard, Graupera, Judith Lacasa, Nabrotzky, Ruebel, Valdés, von Wittich

Courses for Graduate Students, minor only

French (Frnch)

401, 402. Advanced Composition and Conversation. (3-0) Cr. 3 each. 401: F; 402: S. *Prereq: 301 or 302.* Intensive practice in composition and conversation. Development of an appreciation for style, idiomatic usage, and effective expression of ideas. Increased emphasis on vocabulary building, grammatical correctness and compatibility of style and content.

441. Literature of the Renaissance. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 242 and 301 or 302.* Major writers of sixteenth century prose and poetry, including Rabelais, Montaigne, Marguerite de Navarre, the Pléiade, the *Ecole de Lyon.* Literary movements in the context of the two major historical phenoma of the century, Humanism and the Reformation.

442. Literature of the Romantic and Symbolist Movements. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 242 and 301 or 302.* The evolution of Romanticism, its flowering and decline. Origins and development of the Symbolist movement. Detailed *explications de texte* of poetic works of Hugo, de Vigny, Nerval, Baudelaire, Rimbaud, Verlaine, and Mallarmé. Prose works of Chateaubriand, Balzac, Stendhal, and Flaubert.

443. Classical and Baroque Literature. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 242 and 301 or 302.* Study of works of representative authors mostly from the seventeenth century. Includes the theater of Corneille, Molière and Racine, poetry and novels of Théophile, Saint-Amant, LaFontaine, Boileau, and other prose works of Cyrano, Pascal, and LaBruyère.

444. Literature of the Modern Period. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 242 and 301 or 302.* Representative authors of the twentieth century: Proust, Gide, Claudel, Giraudoux, Sartre, Camus, Malraux, Mauriac. New-Theater, New-Novel, and more recent developments. May also include predecessors from the late nineteenth century.

480. Seminar in French Literature. (3-0) Cr. 3. *Prereq: 242 and 301 or 302, one 400 level literature course.* Study of a selected topic in literature or literary criticism.

490. Independent Study. Cr. 1-6 each time taken. *Prereq: Permission of department head.* Designed to meet the needs of students who seek work in areas other than those in which courses are offered, or who desire to integrate a study of literature or language with special problems in major fields.

German (Ger)

401, 402. Advanced Composition and Conversation. (3-0) Cr. 3 each. 401: F, 402: S. *Prereq: 401: 302; 402: 401.* Study of syntax, modes of expression. Intensive practice in composition and conversation based on selected readings.

440. Topics in German Literature. (3-0) Credit 3. F. *Prereq: 302 or 322.* Studies in periods, genres, or individual authors. May be repeated for different offerings to a maximum of 6 credits.

441. Enlightenment — Storm and Stress (3-0) Cr. 3. Alt. F, offered 1982. *Prereq: 302 or 322.* Readings in German literature of the Enlightenment and Storm and Stress periods.

442. Classicism-Romanticism. (3-0) Cr. 3. Alt. F, offered 1983. *Prereq: 302 or 322.* Readings in German literature of the Classical and Romantic periods (to 1830).

443. Nineteenth Century German Literature. (3-0) Cr. 3. Alt. F, offered 1981. *Prereq: 302 or 322.* Readings in German literature from 1830 to 1914.

444. Twentieth Century German Literature. (3-0) Cr. 3. Alt. S, offered 1982. *Prereq: 302 or 322.* Readings in German literature from 1914 to the present.

490. Independent Study. Cr. 1-6 each time taken. *Prereq: Permission of department head.* Designed to meet the needs of students who seek work in areas other than those in which courses are offered, or who desire to integrate a study of literature or language with special problems in major fields.

Russian (Rus)

401, 402. Advanced Composition and Conversation. (3-0) Cr. 3 each. Alt. Yr., offered 1981-1982. 401: F; 402: S. *Prereq: 401: 302; 402: 401.* Writing, speaking, analysis of grammar.

441, 442. Literary Masterpieces of the Nineteenth and Twentieth Centuries. (3-0) Cr. 3 each. Alt. Yr., offered 1981-82. *Prereq: 301 or 302.* Readings, discussions, and compositions based on the works of Pushkin, Lermontov, Gogol, Turgenev, Tolstoy, Dostoevsky, Chekhov, Gorky, Pasternak, Solzhenitsyn.

490. Independent Study. Cr. 1-6 each time taken. *Prereq: Permission of department head.* Designed to meet the needs of students who seek work in areas other than those in which courses are offered, or who desire to integrate a study of literature or language with special problems in major fields.

Spanish (Span)

401, 402. Advanced Composition and Conversation. (3-0) Cr. 3 each. 401: F; 402: S. *Prereq: 401: 302; 402: 401.* Intensive practice in composition and conversation. Development of idiomatic usage and effective expression of ideas. Increased emphasis on vocabulary building, grammatical correctness, and compatibility of style and content.

451. Spanish Literature of the Renaissance and the Golden Age. (3-0) Cr. 3. *Prereq: 322.* Alt. F, offered 1981. Discussion and analysis of representative works of Renaissance and Golden Age prose, drama, and poetry.

452. Spanish Literature from the Early 19th Century into the 20th Century. (3-0) Cr. 3. *Prereq: 322.* Alt. S, offered 1983. Discussion and analysis of representative works, authors, and literary trends from Romanticism to Naturalism or from the Generation '98 to the present.

454. Trends and Major Figures in Literature of Spanish America from Colonial Times to Independence. (3-0) Cr. 3. *Prereq: 322.* Alt. S, offered 1982. Study and analysis of representative works, literary schools, and movements of this period.

455. Trends and Major Figures in Literature of Spanish America from Post-Independence to the Present. (3-0) Cr. 3. Alt. F, offered 1982. *Prereq: 322.* Critical and analytical study of the foremost Spanish American narrative, poetry, and drama.

480. Seminar in Hispanic Literature. (3-0) Cr. 3. S. *Prereq: 322.* Study of a selected topic in Hispanic literature or literary criticism.

490. Independent Study. Cr. 1-6 each time taken. *Prereq: Permission of department head.* Designed to meet the needs of students who seek work in areas other than those in which courses are offered, or who desire to integrate a study of literature or language with special problems in major fields.

497. Spanish Syntax. (3-0) Cr. 3. F. *Prereq: Permission of instructor.* Structure of sentences, based on the Spanish Academy's system of grammatical analysis. Emphasis on problems faced by the English-speaking student.

Special Courses in Foreign Languages (F Lng)

491. Linguistics for Foreign Language Teaching. (3-0) Cr. 3. F. *Prereq: Reading knowledge of Latin or a modern Romance language.* Phonetics, phonology, and morphology of French and Spanish. Theories of syntax and semantics. History and analysis of language teaching methods. Psychology of the foreign language learner. Selection and preparation of materials.

492. History of the Romance Languages. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: Reading knowledge of Latin or a modern Romance language.* From pre-classical Latin to the modern Romance languages, emphasizing both internal history (changes in sounds and forms) and external history (the social, political, and geographic context in which the language is spoken). Methods of historical linguistics. Readings in earliest texts.

Forestry

George W. Thomson, Chair of Department

The Graduate Faculty

Members: Bensend, Hinz, Manwiller, McNabb, Scholtes, Schultz, Thomson

Associate Members: Colletti, Countryman, Hall, Hopkins, Jungst, Kuo, Mize, Prestemon, Wray

The department offers work for the degrees Master of Science and Doctor of Philosophy with a major in forestry and minor work to students taking major work in other departments. Areas of specialization for the M.S. degree are: forest administration and management, forest biology, forest biometry, forest economics and marketing, and wood science. Areas of specialization for the Ph.D. are: forest biology-wood science, forest biometry, and forest economics. This graduate program is open to and suitable for students who have majored in forestry or related natural resource fields. A nonthesis master's option is available. All students are required to teach and conduct research as part of their training for the Ph.D. degree.

The department also participates in the interdepartmental program of Water Resources (See *Index.*)

Courses for Graduate Students, minor only

301. Silvics. (3-3) Cr. 4. F. *Prereq: 201, Bot 207.* Effects of genetic, physiological, and environmental factors on processes underlying forest tree and stand growth.

302. Silviculture. (3-3) Cr. 4. *Prereq: 301.* Manipulation of forest vegetation based on ecological principles for the production of timber and other goods and services.

342. Dynamics of Forest Stands. (2-3) Cr. 3. S. *Prereq: 241.* Examination of factors affecting individual tree and forest growth. Estimation of growth and yield of even-aged and all-aged stands.

344. Forest Resource Surveys. (2-2) Cr. 3. F. *Prereq: Stat 104, a course in natural resources.* Measurement and inventory techniques applicable to various forest resources such as fisheries, range, recreation, water, and wildlife.

380. Basic Properties and Proper Use of Wood. (3-0) Cr. 3. F. *Prereq: Biol 110.* Consideration of important basic, solid wood properties and how such properties relate to proper use; an overview of solid, glued, and fiber products; wood use trends and raw material base for forest products.

380L. Wood Anatomy and Identification. (0-3) Cr. 1. F. *Prereq: Classification in 380.* Minute structure of wood, comparative anatomical characteristics and hand lens identification of commercially important native woods.

390. Forest Fire Protection and Management. (3-0) Cr. 3. F. *Prereq: 201.* Characteristics and role of fire in forest ecosystems. Major topics covered include fuels, fire weather, fire behavior, fire danger rating systems, fire control, and prescribed burning.

407. Forest Influences. (2-2) Cr. 3. F. *Prereq: 301, a course in soils.* Forest-water relationships: yield, regimen, quality. Use of trees as environmental modifiers: micro-climate, noise abatement, wildlife habitat, water, and soil reclamation.

***414. General Photogrammetry and Photo-Interpretation.** (C.E. 414) (2-3) Cr. 2. F. *Prereq: 3 professional courses in student's major.* Use of aerial and terrestrial photographs in resource management and research. Techniques of measurement, cartographic methods, and interpretation applicable to controlled photographs. Terminates at end of 11 weeks.

***445. Natural Resource Photogrammetry and Photo-Interpretation.** (2-3) Cr. 3. F. *Prereq: C E 215A.* Use of aerial photos and remotely sensed imagery in resource management with emphasis on multiple-use forestry. Training in techniques of photo measurement, interpretation, and mapping plus procedures for forest inventory. Principles of remote sensing.

451. Forest Resource Economics and Quantitative Methods. (3-2) Cr. 4. S. *Prereq: 241, Econ 201, Math 151.* Application of economic principles to forest resource management. Methods of identifying and specifying problems in the management and use of forest resources. Application of mathematical and statistical models to the solution of managerial problems.

453. Forest Resource Policy. (2-0) Cr. 2. F. *Prereq: 451.* Contemporary forest resource policies and issues. Processes involved in the formulation of public and private policy. Legal opportunities and restraints. Conflict resolution. Historical development of forest resource policy.

454. Forest Resource Case Studies. (1-4) Cr. 3. S. *Prereq: 20 credits in forestry courses at 300 level or above.* Integrated case studies of forest resources management to illustrate methods of synthesizing the economic, mathematical, biological, political, and administrative principles discussed in preceding courses. Field trips and discussion sessions arranged.

470. Resource Allocation in Outdoor Recreation. (2-0) Cr. 2. F. *Prereq: 360, Econ 201.* Analysis of factors affecting recreational use of forest resources. Current recreational issues and problems.

481. Chemical Conversion of Wood and Fiber Products. (2-3) Cr. 3. Alt. S., offered 1983. *Prereq: 380, 380L.* Wood chemistry; pulp and paper; fiber products.

486. Wood Liquid Relations. (2-3) Cr. 3. Alt. S., offered 1982. *Prereq: 380, 380L.* Movement of liquids and gases in wood; seasoning techniques; preservation methods; dimensional stabilization.

491. Forest Range Management. (4-0) Cr. 2. S, first 8 weeks. *Prereq: 3 courses in biological sciences.* The place of the range resource in multiple-use land management. Impact of past practices on the range; present management problems and policies as they concern public and private land managers. Technical questions of computing carrying capacity and balancing competing uses.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Seminar. (1-0) Cr. 1 each time taken. S. *Prereq: Permission of instructor.* Reports of research and current literature.

501. Forest Tree Improvement and Genetics. (2-2) Cr. 3. Alt. F, offered 1981. *Prereq: Gen 320, Agron 421.* Genetic principles as they apply to selection and breeding of forest trees. Variation and genetic systems in trees, selection techniques, polyploidy, floral biology, cloning, hybridization techniques and operational tree improvement programs.

504. Advanced Forest Biology and Silviculture. (4-0) Cr. 4. Alt. F, offered 1982. *Prereq: 301.* Detailed analysis of factors and processes underlying forest and stand growth and development. Applications of this knowledge to forest culture. Experimentation in forest biology.

543. Forest Biometry. (3-0) Cr. 3. Alt. F, offered 1982. *Prereq: Stat 401, permission of instructor.* Estimation of current stand volume and growth. Selection of variables for volume and yield tables. Application of sampling methods to forest resource surveys.

544. Advanced Forest Pest Management. (PP SW 544, Ent 544) See *Plant Pathology, Weed and Seed Sciences.*

570. Resource Allocation in Forestry. (2-2) Cr. 3. Alt. F., offered 1981. *Prereq: 451.* Analytical approach to economic aspects of forest resource management problems. Current problems in the allocation of resources in forestry. Implications of current research for the analyst and manager.

587. Advanced Topics in Wood Science. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 380.* Recent contributions of research and technology to product development. Areas of emphasis in basic and applied research.

590. Special Topics. Cr. 2 to 4 each time elected. *Prereq: 15 credits of acceptable graduate work, permission of the instructor.*
A. Forest Biology
B. Forest Biometry
C. Forest and Recreation Economics
D. Forest Management
E. Wood Science
F. Range Management
G. Forest Photogrammetry
I. Forest Recreation Resource Management

594. Advanced Forest Resource Management. (3-0) Cr. 3. F. *Prereq: 454.* A seminar approach to the critical analysis of forest management problems as exemplified in public agencies and private firms.

599. Research. Cr. 1 to 8.
A. Forest Biology
B. Forest Biometry
C. Forest and Recreation Economics
D. Forest Management and Administration
E. Wood Science

Courses for Graduate Students, major or minor

601. Research Methods. (3-0) Cr. 3. F. *Prereq: Permission of instructor.* Forestry graduate student orientation; departmental research philosophy and program; student and faculty research presentations. Scientific method; hypothesis formulation and testing; project and study planning; preparation and critical analysis of study plans. Communication of research results. Institutional factors in research.

602. Forest Biology Seminar. (1-0) Cr. 1. F. *Prereq: Permission of instructor.* Presentation of papers and discussions of topics on selected areas in advanced forest biology. May be taken up to three times for credit.

645. Advanced Forest Biometry. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 543, Stat 402, permission of instructor.* The theory and application of statistical and mathematical methods to forest measurement. Quantification problems in stand structure and growth. Recent developments in forest biometry.

688. Formation of Wood. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 380.* Structure of cell wall in woody plants. Measures of wood quality; environment as related to quality. Structure as related to the physical properties of wood.

699. Research. Cr. 1 to 8.
A. Forest Biology — Wood Science
B. Forest Biometry
C. Forest Economics

General Graduate Studies

(Interdepartmental Program)

Martin Ulmer, Chair, Supervisory Committee

Supervisory Committee: J. W. Elrod (Arts and Humanities), P.A. Hartman (Biological Sciences), E. C. Jones (International Development Studies), F. C. Peterson (Physical Sciences), M. G. Miller (Social Sciences), L. W. Glass (General)

The degree Master of Science or Master of Arts with major in general graduate studies is available to graduate students who wish to have a more diversified program of advanced tudy than that generally permitted students who specialize in a single subject. The General Graduate Studies program is considered a terminal master's degree; those wishing to pursue the doctorate should enter departmental programs. Those who elect general graduate studies are allowed to take courses in three different approved graduate areas, each subject contributing a minimum of 10 credits toward the 35 graduate credits required for the degree. Each of the three areas chosen must be specifically authorized for major or minor graduate study in the department statement. Courses which may be used for credit toward this degree are selected from those listed in the Graduate College catalog for graduate credit.

Both thesis and nonthesis options are available. If a thesis is chosen, a maximum of 5 credits in Research 699 may be counted in the total of 35 required credits. If the nonthesis option is elected, evidence of original creative effort must be presented. This may be in the form of a demonstration of independent creativity such as a written report of laboratory, field, or library research, a project in fine arts, or some other original contribution acceptable to the student's supervisory committee. In the nonthesis option a maximum of 5 credits in 500-level special topics may be counted toward the total of 35 graduate credits.

A graduate advisory committee, in consultation with the student, will decide on the choice of option. The committee also aids the student in planning a program of study and in selecting appropriate courses.

Foreign language requirements, if any, will be decided by the student's committee.

Although the program is open to any qualified graduate student, it is most useful to those who wish to improve their subject matter competence for teaching, either in high school, college, or university.

Programs in biology, physical sciences, social sciences, humanities, art, or other disciplines can be especially designed for students or teachers who wish to increase their knowledge in several specialized areas.

Students who wish to participate in general graduate studies should communicate with the chairman in charge of the program, or with the chairman of one of the subcommittees.

Genetics

Alan G. Atherly, Chair of Department

The Graduate Faculty

Members: Atherly, Imsande, McDonald, Miller, Palmer, Peterson, Pollak, Robertson, Sadanaga, Stadler, Welshons

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in genetics, and minor work to students taking majors in other departments.

Prerequisite to major work is the completion of a thorough undergraduate curriculum in a biological science, or in a physical science, or in agriculture with evidence of excellent scholarship and aptitude for scientific research.

The department offers the student the opportunity to work in such areas as *Drosophila,* maize, soybean, population, statistical, immunological, microbial, biochemical, developmental, and mammalian cell genetics. Minor work may be taken in agronomy, animal science, bacteriology, biochemistry, botany, horticulture, mathematics, statistics, veterinary medicine, and zoology.

The department also participates in the interdepartmental programs of Molecular, Cellular, and Development Biology; and Immunobiology (See *Index*.)

Courses for Graduate Students, minor only

460. Introduction to Mathematical Genetics. (2-0) Cr. 2. *Prereq: Knowledge of elementary algebra and 320 or 330.* Pollak. Elementary probability and its application to Mendelian population, and quantitative genetics.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501. Hereditary Mechanisms. (2-0) Cr. 2. F. *Prereq: Undergraduate course in biology and genetics.* Topics: Recombinational analysis in procaryotes and eukaryotes, variation in chromosome structure, aneuploidy and euploidy in plants and animals, gene structure and function, and mechanisms of sex determination. Designed primarily for graduate students in an agricultural discipline.

534. Molecular Development and Differentation. (Zool 534) See *Zoology.*

535. Laboratory in Cytogenetics. (0-6) Cr. 2. Alt. S., offered 1983. *Prereq: 501 and Bot 444.* Palmer. Laboratory methods and techniques for cytogenetical research, with emphasis on plants.

536, 537. Genetic Statistics. (Stat 536, 537) See *Statistics.*

550. Population Genetics. (An S 550) See *Animal Science.*

560. Evolutionary Genetics. (2-0) Cr. 2. Alt. F. offered 1983. *Prereq: 330 or 320.* McDonald. Genetic basis of evolutionary process in higher organisms with emphasis on molecular evolution. Topics covered include: alternative strategies of molecular adaptation, origin and evolution of the genome, regulatory vs. structural gene evolution, gene duplication and rearrangement in evolution.

590. Special Topics. (0-3 to 9) Cr. Arr. *Prereq: 330 or 320.*

599. Research.

Courses for Graduate Students, major or minor

610. Genetics of Bacteria and Bacteria Vacteriophage. (Bact. 610) See *Microbiology.*

615. Molecular Immunology. (B B 615) See *Biochemistry and Biophysics.*

619. Developmental Genetics. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 330 and B B 405.* Aspects of cellular development governed by genetic mechanisms. Topics covered include genetic redundancy, interaction of nuclear and cytoplasmic genomes, developmental processes in animals and plants, cell fusion, and genetic manipulation in plants.

620. Molecular Genetics. (Micro 620 B B 620) (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 330 or 320; B B 405.* Atherly. B B 620. Detailed analysis of procaryotic and some eucaryotic genetic material at the molecular level including: replication, transcription, repair, recombination, control of gene expression (bacterial and viral), and genetic engineering using restriction endonucleases.

621. Somatic Cell Genetics. (B B 621) (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 330 or 320 and B B 405.* Stadler. The use of mammalian somatic cells in modern genetic research. Establishment and characterization of primary cell cultures and permanent cell lines. Mutagenesis, cell fusion theory, analysis of cell hybrids, and recent advances in somatic cell genetics.

625. Cytogenetics and Advanced Plant Genetics. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 501.* Robertson. An analysis of chromosomes and their involvement in crossing over, chromosomal aberrations, polyploidy and plant evolution. Gene regulation, cytoplasmic inheritance, and genetic control of meiosis in plants.

675. Nucleic Acids and Gene Regulation. (B B 675). See *Biochemistry and Biophysics.*

690. Seminar. Cr. 1. F.S.

698. Seminar in Molecular, Cellular and Developmental Biology. (MCDB 698) See *Molecular, Cellular and Developmental Biology.*

699. Research.

Geodesy and Photogammetry

For description of courses, see A E 419; C E 315, 317, 412, 417, 418, 510, 512, 513, 514, 515, 519, 616, 618, and For 414.

Geography

For description of course, see *Earth Sciences.*

Geology

For description of courses, see *Earth Sciences.*

Gerontology

(Interdepartmental Minor)

D. C. Charles, Chair, Supervisory Committee

Supervisory Committee: P. A. Garcia, W. Hutchison

Work is offered for an interdepartmental graduate minor with the following departments participating in the program: Architecture, Biochemistry and Biophysics, Business Administration, Economics, Family Environment, Food and Nutrition, Home Economics Education, Physical Education, Political Science, Professional Studies in Education (Adult Education), Psychology, Sociology and Anthropology, Speech, and Textiles and Clothing.

A declared graduate minor in gerontology consists of a minimum of 12 credits taken from a list of acceptable courses, and from at least two departments. Nine of these 12 credits will be in courses focused specifically on aging. At least one member of the gerontology forum will be on a student's advisory committee; this person must be at least an associate member of the Graduate Faculty for a master's committee and a full member for a doctoral committee. Because gerontology is a rapidly developing area, departments participating in the minor and specific course offerings may change in the future. Contact the chair of the supervisory committee for information on the program and for the list of courses in the graduate minor in gerontology.

History

Richard Lowitt, Chair of Department

The Graduate Faculty

Members: Apt, Cravens, Dobson, Keller, Kottman, Lowitt, McAuliffe, McJimsey, Plakans, Schofield, Wilson, Wilt

Associate Members: Avraamides, Bennett, McCarthy, Madison, Osborn, Rawson, Whitaker, Wilt

The department offers work for the Master of Arts degree with major in history, for the Master of Arts and Doctor of Philosophy degrees with major in history of technology and science, and minor work for students majoring in other departments. For admission and degree requirements for work in history of technology and science, see separate department brochure.

For the M.A. in history, students may elect a thesis or a nonthesis program. The foreign language requirement or an alternate requirement, such as computer science or statistics, is determined by the student's advisory committee.

The Master of Arts in history program serves as a basis for continued study in history, law, or business; preparation for teaching in high school or junior college; preparation for government service; or as part of a general education.

The department participates in the interdepartmental program of Technology and Social Change. (See Index.)

A history graduate student may take any 400-level course for major graduate credit; however, no more than 12 credits of 400-level courses may be used toward the minimum credits required for the degree as listed on the program of study. Additional work is required for graduate credit.

Courses for Graduate Students

History of Europe (Hist)

401. Ancient Near East. (3-0) Cr. 3. F. Avraamides. Political, socio-economic, artistic, and religious history of ancient Mesopotamia and Egypt.

***402, 403. Ancient Greece and Rome.** (3-0) Cr. 3 each. F.S. Avraamides. 402: Ancient Greece from the Bronze Age to the Hellenistic Kingdoms; the evolution of the Greek polis and its cultural contributions. 403: Ancient Rome from the founding of the city of Rome to the rise and decline of the Roman Empire; its political and administrative institutions and cultural contributions.

***405, 406. History of Medieval Western Europe.** (3-0) Cr. 3 each. F.S. Madison. Development of political, economic, and social institutions. 405: Early and Central Middle Ages, 284-1050. 406: High and Late Middle Ages, 1050-1500.

407. Medieval and Renaissance Italy. (3-0) Cr. 3. F. Madison. Development of the city-republics, rise of the signori, new intellectual directions, and historiography.

408. Europe, 1500-1648. (3-0) Cr. 3. Alt. S. Zaring. The Northern Renaissance; the Church and Luther; Protestant reform and Roman-Catholic counter-reform; social, cultural, and economic changes; Spain in triumph and decline; religious wars and the emergence of France.

410. 19th Century Europe. (3-0) Cr. 3. S. Apt. Europe in the age of nationalism, revolution, and imperialism.

***411, 412. Contemporary Europe.** (3-0) Cr. 3 each. F.S. Wilt. 411: Europe from the 1890s to the 1930s. 412: Europe since the 1930s with emphasis on the origins, course, and effects of World War II.

414. European Intellectual History. (3-0) Cr. 3. Alt. F. Apt. Modern European thought, 1600-1950.

416. European Society in the Age of Enlightenment. (3-0) Cr. 3. Alt. F., offered 1982. Plakans. Europe from the mid-seventeenth century to the French Revolution, with emphasis on social structure and on the culture of the traditional social orders.

417. European Society and the Industrial Revolution. (3-0) Cr. 3. Alt. S., offered 1983. Plakans. England and the continent during the period of European industrialization (1750-1900), with emphasis on the relationship between industrial and social change.

419. French History. (3-0) Cr. 3. Alt. F. Apt. Modern French history, 1600 to the present.

***421, 422. History of Russia.** (3-0) Cr. 3 each. Yr. Rawson. 421: Russia to 1825. Origins of the Russian people; Byzantine influences; Mongol invasion; rise of Moscow; advent of Westernization. 422: Russia since 1825. The role of autocracy; era of reforms; conflict between state and society; revolution; transformation of society in the Soviet period; the USSR as a world power.

424. History of Modern Germany. (3-0) Cr. 3. Alt. S., offered 1982. Wilt. Cultural, economic, and political developments in nineteenth and twentieth century Germany.

426. Modern East Central Europe. (3-0) Cr. 3. Alt. S., offered 1982. Plakans. Political, social, and cultural developments in Czechoslovakia, Poland, the Baltic States, Hungary and the Balkans during the nineteenth and twentieth centuries. Rise of nationalism; creation of independent states; agrarian reform; emergence of communist governments.

***427, 428. Medieval England.** (3-0) Cr. 3 each. F.S. Madison. Medieval English society and government examined through contemporary sources in translation. Legal and constitutional developments emphasized. 427: Anglo-Saxon, Norman, and Angevin England, c. 342-1189. 428: Plantagenet, Lancastrian, and Yorkist England, 1189-c. 1509.

***430, 431. Modern England.** (3-0) Cr. 3 each. F.S. Zaring. 430: England from 1688 to 1830. Political, social, cultural, economic development; England as a great power. 431: England since 1830. Parliamentary and constitutional development; social reform and economic change; imperial Britain; the welfare state.

History of Asia, Africa, Latin America (Hist)

436. Modern Japanese History. (3-0) Cr. 3. Alt. F. Bennett. Japan 1600 to the present; emphasis on the transformation of feudal Japan into a post-industrial society.

441. History of Mexico. (3-0) Cr. 3. S. Osborn. Colonial background and the history of Mexico since independence with emphasis on the significance of the Mexican Revolution for the development of contemporary Mexico.

History of the United States (Hist)

450. Colonial America. (3-0) Cr. 3. F. Keller. Exploration, colonization, and development of political, economic,

social, and cultural institutions of the North American colonies before 1754.

451. American Revolution. (3-0) Cr. 3. S. Keller. Participants, ideas, and events leading to independence and the foundation of the American Republic, 1754 to 1787.

452. The New Nation. (3-0) Cr. 3. Alt. F. Development of the political institutions and the social, economic, and cultural fabric of the new nation from 1787 to 1828.

454. Politics and Sectional Conflict. (3-0) Cr. 3. F. McJimsey. Origins of second party system. Social and economic forces that sustained the system and ultimately caused its collapse and sectional division, 1815-1861.

455. The Civil War and Reconstruction. (3-0) Cr. 3. S. McJimsey. Emphasis on military and political events of the Civil War and their influence on postwar America, 1861-1877.

457. The Populist-Progressive Years. (3-0) Cr. 3. S. Dobson. The United States' transition from an agrarian society to a mature industrial giant, emphasizing political, economic, and social developments of the late 19th and early 20th centuries.

***458, 459. U.S. Since World War I.** (3-0) Cr. 3 each. F.S. Lowitt, Kottman. 458: America in depression and war. Major developments of the nation, 1919-1950; new economic era; Hoover and depression, New Deal, World War II, and Cold War. 459: Contemporary America. Major developments of the nation since 1950; Korean War; modern Republicanism; New Frontier and the Great Society; Vietnam, social disturbances, and conservative resurgence.

***462, 463. American Thought and Culture Since 1607.** Cr. 3 each. Alt. F.S. Cravens. 462: F; 463: S. American cultural values and social and political thought from the seventeenth century to the present. 462: The rise of the middle-class republic, 1607-1865; the role of religion, rationalism, and republicanism in the seventeenth and eighteenth centuries; Enlightenment and Revolution; the Revolution's legacy; the democratic mode in politics, religion, the economy, society, and culture; impact of Civil War and industrialization. 463: American democracy in the Machine Age, 1865 to the present; multimedia inquiry into social thought, moral values, and culture in the urban-industrial era; 1920-1945 as a turning point; the contemporary situation.

464. Nineteenth Century American Social History. Cr. 3. Alt. S. Schwieder. Rise of modern industrial society in nineteenth century America; the family, churches, and other social institutions; immigration, social and geographical mobility; social, economic, and ethnic stratification.

465. The Westward Movement and Frontier Development. (3-0) Cr. 3. S. Whitaker. Occupation, distribution, and political organization of the public domain; Indian-white relations; economic exploitation of the public domain (trapping, mining, lumbering, ranching, farming), and social adjustments (law and order, religion, education, and culture).

***467, 468. History of United States Foreign Policy.** (3-0) Cr. 3 each. F.S. Dobson, Kottman. Diplomatic history emphasizing the growth of American influence around the world and the resulting consequences and conflicts. 467: Diplomacy from the American Revolution; America's rise as a world power; the First World War and post-war entanglements.
468: Diplomacy from the 1930s to the present including U.S.-Soviet Relations, the Second World War, and the Cold War.

History of Technology and Science (Hist)

480. History of Agricultural Sciences and Technology. (3-0) Cr. 3. Alt. S., offered 1983. Marcus. Rise of mechanization and scientific agriculture since the industrial revolution, set in the social and cultural context of the western world.

481. History of Chemical Sciences and Their Technologies. (3-0) Cr. 3. Alt. F., offered 1981. Schofield. Development of theories and processes relating to the nature and transformation of matter in chemistry and associated engineering fields. Emphasis on chemistry and chemical theory since the seventeenth century and on the creation of concepts and processes for the controlled production of substances on an industrial scale since the eighteenth century.

482. History of the Life Sciences and Their Applications. (3-0) Cr. 3. Alt. F., offered 1981. Cravens. Emergence of the human sciences and technologies — medicine, physiology, cytology, public health, and social sciences — in the social and cultural context of the western world. Emphasis on developments from Darwin and Pasteur to the present.

485. History of Physics and Physical Engineering. (3-0) Cr. 3. Alt. S., offered 1982. Wilson. Interactions between the science of physics and the branches of engineering associated with it, from the post-Newtonian era to the age of Einstein.

486. Problems in Nineteenth and Early Twentieth Century Physics. (3-0) Cr. 3. Alt. S., offered 1983. Wilson. A study of two revolutions in physics: the nineteenth-century creation of thermodynamics and the science of the ether and twentieth century revolution associated with Einstein and Bohr.

488. History of American Technology. (3-0) Cr. 3. Alt. F., offered 1981. Marcus. Technology in America with emphasis on the industrial revolution and its consequences. American invention and its relation to science; technology as social response and perception of it as social problem; locus of support for process of technological innovation.

489. History of American Science. (M E 489) (3-0) Cr. 3. Alt. S. Offered 1982. Cravens. Science and its social relationships since the mid-nineteenth century; interaction of scientific discoveries and the development of society. Continuing impact of Darwinism and other scientific theories; science and social thought; modern medicine and public health; science and industry; science and agriculture; the social sciences; government and science; science and the consumer; the atomic age; big science and the environmental dilemma; the energy crisis; the role of science in a democracy.

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*Any course may be taken independently.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

History of Europe (Hist)

512. Proseminar in European History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Readings in European History.
A. Ancient
B. Medieval
C. Modern

594. Seminar in European History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Topics vary each time offered.
A. Ancient
B. Medieval
C. Modern

History of Asia, Latin America (Hist)

510. Proseminar in East Asian History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Readings in East Asian History. Topics vary each time offered.

513. Proseminar in Latin American History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Readings in Latin American history. Topics vary each time offered.

592. Seminar in East Asian History. (3-0) Cr. 3. S. *Prereq: Permission of instructor.* Topics vary each time offered.

595. Seminar in Latin American History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Topics vary each time offered.

History of the United States (Hist)

511. Proseminar in American History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Readings in American history. Topics vary each time offered.
A. Colonial period
B. Nineteenth century
C. Twentieth century

593. Seminar in American History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Topics vary each time offered.
A. Colonial Period
B. Nineteenth Century
C. Twentieth Century

Topical Courses

514. Proseminar in Comparative Economic History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Readings in comparative economic history. Topics vary each time offered.

580. Museum Internship. Cr. varies each time taken. *Prereq: 15 graduate credits in history; permission of instructor.*

583. Historical Methods. (3-0) Cr. 3. *Prereq: Permission of instructor.* Original sources, bibliography, criticism of evidence, form, statistical analysis.
A. Written evidence and analysis
B. Statistical evidence and analysis

585. Teaching Methods. Cr. 1 to 3 each time taken. *Prereq: Permission of instructor.* Topics vary each time offered.
A. Teaching Methods
B. Curriculum Development in History
C. Implementing Teaching Techniques

590. Special Topics. Cr. 1 to 3 each time taken. *Prereq: Permission of instructor.*

597. Seminar in Comparative Economic History. (3-0) Cr. 3 each time taken. *Prereq: Permission of instructor.* Topics vary each time offered.

598. Introduction to Archives and Special Collections. (3-0) Cr. 2 each time taken. *Prereq: Graduate classification.*

History of Technology and Science (Hist)

The graduate program in history of technology and science has been restructured with a new sequence of courses leading to the M.A. and Ph.D. degrees.

570, 571. Seminar in General History of Science I, II. (3-0) Cr. 3 each. Yr. Wilson. The history of science from pre-classical civilizations to the Age of Galileo, and from Galileo to modern times, with emphasis on the historical literature, varying interpretations of the period, and problems for continuing research.

574, 575. Seminar in General History of Technology I, II. (3-0) Cr. 3 each. Yr. Marcus. The history of technology from pre-classical civilizations to the eve of the Industrial Revolution, and from the Industrial Revolution to modern times, with emphasis on the historical literature, varying interpretations of the period, and problems for continuing research.

576, 577. Proseminar in Historiography of Technology and Science I, II. (3-0) Cr. 3 each. Yr. Schofield. Investigation in the bibliography, philosophy, and professional problems of the history of technology and science. Required of all graduate students in the history of technology and science program.

Courses for Graduate Students, major or minor

600. Seminar in Seventeenth and Eighteenth Century Science. (3-0) Cr. 3. Alt. F., offered 1982. Schofield. *Prereq: Permission of instructor.* Emphasis varies each time offered.

601. Seminar in Seventeenth and Eighteenth Century Technology. (3-0) Cr. 3. Alt. S., offered 1983. Schofield. *Prereq: Permission of instructor.* Emphasis varies each time offered.

602. Seminar in Nineteenth Century Science. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: Permission of instructor.* Emphasis varies each time offered.

603. Seminar in Nineteenth Century Technology. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: Permission of instructor.* Emphasis varies each time offered.

604. Seminar in American Science. (3-0) Cr. 3. Alt. S., offered 1982. Cravens. *Prereq: Permission of instructor.* Emphasis varies each time offered.

605. Seminar in American Technology. (3-0) Cr. 3. Alt. F., offered 1981. Marcus. *Prereq: Permission of instructor.* Emphasis varies each time offered.

606. Seminar in Early Twentieth Century Science. (3-0) Cr. 3. Alt. S., offered 1983. Wilson. *Prereq: Permission of instructor.* Emphasis varies each time offered.

607. Seminar in Early Twentieth Century Technology. (3-0) Cr. 3. Alt. F., offered 1982. Marcus. *Prereq: Permission of instructor.* Emphasis varies each time offered.

699. Research.

Home Economics Education

Ruth P. Hughes, Head of Department

The Graduate Faculty

Members: Beavers, Fanslow, Hughes

Associate Members: Amos, Hausafus, Ralston, Schultz, Williams

The department offers work for the degrees Master of Science, Master of Education, and Doctor of Philosophy with major in home economics education. Minors are available for students who are majors in other departments.

Students majoring in home economics education should have fundamental knowledge of psychology, education, sociology, and home economics. Each program of study is planned to meet individual needs.

Courses in statistics are included in the program of study for the Master of Science and Doctor of Philosophy degrees with a higher level of competence required for the degree of Doctor of Philosophy.

Courses for Graduate Students, minor only

410. Educational Principles for Home Economics Offerings. (2-0) Cr. 2. F.S. *Prereq: 20 hours in home economics subject matter.* Use of principles of learning in developing instructional strategies and evaluation techniques. Program development appropriate for formal and informal offerings in home economics.

413. Educational Strategies for Home Economics Areas. (0-3) Cr. 1. S. *Prereq: Classification in 410.* Application of methods and techniques for teaching home economics in formal and informal settings. Not open to those with credit in 411, 412. Fee.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

500. Short Courses. Cr. Arr. SS. *Prereq: Permission of instructor.*
A. Adult Education
C. Curriculum
D. Evaluation
F. Supervision
I. Teacher Education
M. Teaching Strategies

505. Workshop. Cr. 1 or 2. SS. *Prereq: Permission of instructor.* Concentrated group study of problems in fields of home economics education. Sections offered will vary from year to year.
A. Adult Education
C. Curriculum
D. Evaluation
F. Supervision and Administration
G. General
N. Human Relations
O. Future Homemakers of America
P. Special Needs

507. Curriculum Development in Teaching Vocational Home Economics. (3-0) Cr. 3. F. Alt. SS., offered 1982. *Prereq: Teaching experience.* Application of new knowledge, career development and educational theory to curriculum planning in both consumer and homemaking and occupational programs. Coordination and laboratory techniques for occupational programs included.

508. Methods of Teaching Adult Vocational Home Economics. (2-0) Cr. 2. S. First 8 weeks. *Prereq: 411.* Planning and organizing adult home economics education programs for young, middle-aged, and older adults. Selection, use, and evaluation of teaching techniques suited to group work with adults and to informal education in home economics.

511. Research Design in Home Economics Education. (2-0) Cr. 2. F. Alt. SS., offered 1983. *Prereq: Credit or classification in Res Ev 550 or Stat 401.* Exploratory, descriptive, analytical, experimental, and historic research designs. Needed research in home economics education. Planning a research study. Evaluation of research reports.

515. Evaluation in Home Economics. (3-0) Cr. 3. S. Alt. SS., offered 1982. *Prereq: 410.* Selection and construction of evaluation devices; their use and interpretation in home economics. Procedures for assessing effectiveness of programs.

520. Supervision in Home Economics. (2-0). Cr. 2. Alt. S., offered 1982; Alt. SS., offered 1983. Principles and functions of supervision emphasizing observation, conferences, and evaluation. Application to student teaching, adult education experiences, state department of education, and other supervisory situations.

590. Special Topics. Cr. Arr. *Prereq: 6 credits in education or educational psychology.*
A. Adult Education
B. Administration
C. Curriculum
D. Evaluation
E. Extension
F. Supervision
G. General
I. Teacher Education
J. Research Methodology
K. Occupational Education
N. Human Relations
P. Special Needs
R. Vocational Education

Courses for Graduate Students, major or minor

601. Philosophy of Home Economics Education. (1-0) Cr. 1. F. *Prereq: H St 420, HPC 581.* Integrating philosophies of education and home economics into an operative philosophy.

607. Home Economics Curricula. (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 507.* Curriculum theory, development and implementation applied to home economics. Current curriculum problems explored.

608. Adult Education in Home Economics. (2-0) Cr. 2. Alt. SS., offered 1983. *Prereq: 508 or experience in adult education.* Philosophy of adult education in home economics. Latest research findings in the field of adult and family life education. Emphasis on planning family life courses for informal adult education programs.

610. Seminar. Cr. 1 each semester. F.S. Offered on satisfactory-fail basis only.

611. Research Development in Home Economics Education. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 511 and Res. Ev. 553 or Stat 402.* Design and critique of research studies. Investigate sources of external funding. Proposal writing and research reporting.

615. Program Evaluation in Home Economics. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 515.* Program and curriculum evaluation methodology. Analysis of selected evaluation studies. Experience with a current evaluation problem.

618. Administration of Teacher Education Programs in Home Economics. Cr. 1 to 2. F.S. *Prereq: Master's degree in home economics or education.* May be taken more than once for credit. Study of current undergraduate programs in home economics education; observation and participation in ongoing undergraduate courses including student teaching experiences. Provides background for those preparing to assume administrative roles in teacher education. Offered on satisfactory-fail basis only.

620. Administration in Home Economics. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: Graduate work in home economics or higher education.* Study of home economics in higher education, with emphasis on land grant institutions. Administrative roles and their interrelationships. Discussion of current issues and trends in home economics and higher education.

699. Research.

Home Economics Studies

Julia F. Anderson, Chair of Department

The Graduate Faculty

Members: Anderson, Deacon, Heltsley, Hilton

Assistant Member: Meixner

Courses for Graduate Students, major or minor.

540. Seminar. Cr. 1-3. F.S.

590. Special Topics. Cr. arr.

Horticulture

Charles V. Hall, Head of Department

The Graduate Faculty

Members: Denisen, Hall, Hodges, Kelley, Mahlstede, Weigle

Associate Members: Bauske, Bhella, Buck, Christians, Domoto, Durso, Gladon, Summers, Taber

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in horticulture, and minor work for students taking work in other departments. Under special circumstances a nonthesis master's degree is available.

Prerequisite to major graduate work is the completion of courses covering horticulture, botany, and the underlying sciences.

Students taking major work in horticulture usually will take minor work in agronomy, genetics, botany (physiology, pathology, cytology, or morphology), entomology, statistics, or chemistry.

There is no uniform foreign language requirement for either the Master of Science or the Doctor of Philosophy degree.

The department also cooperates in the interdepartmental program of Water Resources. (See *Index*.)

Courses for Graduate Students, minor only

432. Retail Floriculture. (2-2) Cr. 3. F. *Prereq: 231, 332, permission of the instructor.* Florists' qualifications, business aspects, professional organizations in the industry, and merchandising. Laboratories include designing and servicing floral displays and judging floral quality. Extensive reading required. Fee for field trips. Plant materials fee.

433. Tropical and Subtropical Ornamental Plants. (2-2) Cr. 3. S. *Prereq: Bot 306.* Origin, identification, classification, and description of conservatory plants.

442. Nursery Management. (2-2) Cr. 3. S. *Prereq: 221, Agron 154.* Equipment, including land, packing sheds, storage sheds, frames, glasshouses, and irrigation devices; transplanting and management of plants; relation to other fields of horticulture; protection of nursery plants from climatic, disease, and insect difficulties.

461. Small Fruits. (1-2) Cr. 2. S. *Prereq: 221.* Principles and practices involved in handling home and commercial vineyards and plantations of strawberries, bush fruits, and miscellaneous small fruits.

462. Fruit and Nut Culture. (2-2) Cr. 3. S. *Prereq: 221.* Principles and practices of fruit and nut culture and production. Planting, pruning, propagation, maintenance, pest control, and physiology of growth and development.

471. Vegetable Crops. (3-0) Cr. 3. S. *Prereq: 221, Agron 154.* Principles and practices of vegetable production. Methods of maximizing yield and quality of vegetables. Harvesting, storage, and marketing.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

521. Controlled Plant Environments. (2-3) Cr. 3. Alt. SS., offered 1983. *Prereq: Bot 310 or 320; Phys 111 and 112.* Principles, methods, and techniques related to the measurement and control of environmental factors affecting plant growth under controlled conditions. Emphasis is placed on light, temperature, humidity, carbon dioxide, water, air movement, and related factors. Design and specification of a chosen controlled environment is emphasized.

522. Postharvest Physiology. (2-3) Cr. 3. Alt. F., offered 1981. *Prereq: Bot 310 or 320; B B 301.* Principles, methods, and techniques related to the production and maintenance of quality of horticultural commodities. Emphasis is placed on handling, storage facilities and techniques, quality evaluation, and the physiological mechanisms related to maturation, ripening, and senescence.

525. Breeding and Genetics of Horticultural Plants. (2-2) Cr. 3. Alt. S., offered 1982. *Prereq: Gen 320; Agron 421.* Specialized breeding techniques and methods required for the improvement of horticultural plants and of the genetics of these plants.

551. Growth and Development of Perennial Grasses. (Agron 551) (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: Bot 310 or 320.* The grass plant. Selected topics on anatomy, morphology, and physiology relative to growth and development of perennial grasses. Emphasis on growth and development characteristics peculiar to grasses and variations of such characteristics under natural and managed conditions.

561. Fruit Science. (1-2) Cr. 2. Alt. F., offered 1982. *Prereq: 462; Bot 310 or 320.* Selected topics in fruit growth and development. Emphasis on environmental, hormonal, and nutritional factors as related to orchard cultural practices.

571. Vegetable Science. (2-3) Cr. 3. Alt. F., offered 1981. *Prereq: 471; Bot 310; Gen 320.* Review and discussion of current literature concerning genetics, physiology, and culture of vegetables with emphasis on application of current principles to vegetable production problems.

590. Special Topics. Cr. arr. *Prereq: A major or minor in horticulture.*

599. Creative Component. Cr. arr.

Courses for Graduate Students, major or minor

610. Graduate Seminar. Cr. 1 each time elected. F.S.

624. Reproduction Physiology. (2-3) Cr. 3. Alt. S., offered 1983. *Prereq: 332; Bot 404, 512, 513.* An in-depth, critical examination of selected topics within the physiology of sexual and asexual plant propagation. Physiology of phytochrome, dormancy, germination, root initiation and development, pollination, fertilization, pollen-stigma compatibilities and incompatibilities.

690. Research Topics. Cr. arr. *Prereq: A major in horticulture.*

699. Thesis and Dissertation Research. Cr. 1 to 11.
A. Floriculture
B. Nursery Crops
C. Turfgrass
D. Fruit Crops
E. Vegetable Crops
F. Cross-Commodity

Housing

(Interdepartmental Minor)

G. E. Bivens, Chair, Supervisory Committee

Supervisory Committee: T. A. Barton, S. R. Greenfield, R. G. Mahayni, J. H. Sontag

Work in housing is offered for the degrees Master of Architecture, Master of Landscape Architecture, Master of Arts or Master of Science as appropriate in the following cooperating departments or major areas: Art and Design, Architecture, Family Environment, Landscape Architecture or Community and Regional Planning.

A student in housing will major in one of the cooperating departments and will develop a program for study under the guidance of a committee nominated by the advisory committee and appointed by the dean of the Graduate College.

The major professor will be in the cooperating department in which the student majors. The degree will be in the major department with a minor in housing.

Programs in housing should be planned to include courses from several of the following departments:

Art and Design: 590E, 699

Architecture: 466, 467, 468, 507, 563, 566, 577, 590.

Construction Engineering: 371, 372.

Economics: 401, 402, 405, 461, 480, 565, 566.

Family Environment: 412*, 415*, 446*, 488*, 504, 510, 519, 521, 540, 590B, 591B, 604B, 699B.

Landscape Architecture: 590, 650, 699.

Political Science: 410, 471, 476, 510, 512, 571, 590G.

Sociology: 410, 411, 415, 464, 550, 555, 575, 576.

Statistics: 401, 402, 421.

Community and Regional Planning: 380*, 383*, 395*, 405*, 492*, 511, 515, 520, 524, 527, 561, 575, 590, 592.

*Graduate credit not available to majors in this department.

Immunobiology

(Interdepartmental Program)

D. E. Reed, Chair, Supervisory Committee

Supervisory Committee: D. L. Harris, A. Nordskog, C. D. Thoen, W. J. Zimmerman

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in immunobiology under a cooperative arrangement with the departments of Agronomy, Animal Science, Bacteriology, Biochemistry and Biophysics, Food and Nutrition, Genetics, Veterinary Microbiology and Preventive Medicine, Veterinary Pathology, and Zoology.

Facilities and qualified staff exist in such areas as immunogenetics, physiology of antibody formation, cell-mediated immunity, immunochemistry, immunocytology, immunopathology, microbial immunology, immunoparasitology, and serology.

A student majoring in immunobiology will choose a major professor from the graduate faculty membership of cooperating departments and will develop a program of study under the guidance of a committee nominated by the major professor, approved by the chairman of the immunobiology program, and appointed by the dean of the Graduate College.

Students desiring to do graduate work with a major in immunobiology should have a bachelor's degree or equivalent in one of the areas related to the cooperating departments listed above and should qualify for admission to one of these departments. A strong background in biological sciences is required, including work in immunology, genetics, and biochemistry. Students who do not have these prerequisites should plan to complete them in addition to the regular course requirements for the advanced degree. Proficiency in one foreign language is required for the M.S. and Ph.D. degrees; the same language may serve for both. Proficiency may be demonstrated by passing one year of a collegel-level course or by an alternative, determined by the student's program of study committee, which indicates proficiency in one foreign language. For students whose native language is not English, passing English proficiency examination will fulfill the language requirement.

Immunobiology students should include in their program of study a core of courses which will provide a broad coverage of the basic program in immunobiology. Formal courses in immunochemistry, biochemistry, and statistics are recommended. The following listing should be utilized in the selection of core courses for inclusion in the program.

Courses for Graduate Students, major or minor

489. Principles of Immunology. (VMPM 489) See *Veterinary Microbiology and Preventive Medicine.*

520. Medical Immunology I. (VMPM 520) See *Veterinary Microbiology and Preventive Medicine.*

520L. Medical Immunology Laboratory. (VMPM 520L) See *Veterinary Microbiology and Preventive Medicine.*

560. Immunoparasitology. (VP 560. Micro 560. Zool 560) See *Veterinary Pathology.*

575. Immunology. (Micro 575) See *Microbiology.*

590. Special Topics. Cr. 1 to 3 as arranged. Offered on request. *Prereq: Permission of instructor.* Experimental methods applied in subdisciplines of immunobiology.
A. Immunochemistry
B. Immunocytology
C. Immunogenetics
D. Immunologic Disease
E. Immunoparasitology

595. Immunobiology Seminar. (1-0) Cr. 1. S. *Prereq: Permission of instructor.*

615. Molecular Immunology. (B B 615) See *Biochemistry and Biophysics.*

629. Medical Immunology II. (VMPM 629) See Veterinary *Microbiology and Preventive Medicine.*

631. Immunologic Disease. (VMPM 631) See *Veterinary Microbiology and Preventive Medicine.*

699. Research.

Industrial Administration

See *Business Administration.*

Industrial Administrative Sciences

(Interdepartmental Program)

David B. Vellenga, Chair, Supervisory Committee

Supervisory Committee: W. Q. Meeker, Jr., D. R. Starleaf, V. Tamashunas

Work is offered for the nonthesis degree Master of Science with a major in industrial administrative sciences under an interdepartmental arrangement. Cooperating departments include economics, industrial engineering, statistics and the School of Business Administration. A minor is offered for students majoring in areas other than industrial administrative sciences. The program of formal courses is oriented toward developing administrators or managers for all types of business and governmental organizations. Applicants need not have taken an undergraduate major in business or a related area. However, they are encouraged to obtain background in some of the following: calculus, statistics, accounting, marketing, finance, transportation, economics, industrial engineering, sociology, and psychology.

Students majoring in industrial administrative sciences will choose a major professor from the graduate faculty of industrial administrative sciences. The student's program of study will be developed with the guidance of an advisory committee selected by the student and the major professor, approved by the chairman of the Industrial Administrative Sciences Supervisory Committee, and appointed by the dean of the Graduate College. The program total of 36 semester credits includes work in the areas of human resource management; quantitative methods; economics; the business environment; applications (production, accounting, marketing, transportation and logistics, and finance); business policy; and electives. The program agreed upon by the student and the student's committee shall include a sufficient number of 500 and 600 level courses to be consistent with quality graduate work on the master's level. Although this is a nonthesis degree, a creative component is required of each student. This is accomplished by taking a minimum of three credits in special topics from one of the cooperating departments.

Students minoring in industrial administrative sciences shall have a faculty member representing the interdepartmental program on their committee. At least six courses, one-half of which are on the 500 level, shall be selected from designated course offerings in at least two of the cooperating departments. A minimum of two courses must be included from courses chosen in any of the cooperating departments. A minor cannot include courses that are offered by the department in which the student is a major.

Submission of Graduate Management Admission Test or Graduate Record Examination aptitude test scores is required when seeking admission as a major in the program.

A partial listing of required or recommended courses for a major in industrial administrative sciences is as follows:

Human resource management — selection to be made from Econ 596; I E 424; 425; Psych 450, 451.

Quantitative methods — selection to be made from I E 511, 518; Stat 402; 432, 539.

Economics and the business environment — Econ 495, 496, and Mgmt 510 required.

Applications in business — required courses include Mkt 540, Fin 550, TrLog 560, Acct 580, and one industrial engineering production course, I E 551.

Business policy — Mgmt 578 required.

Electives — courses are selected from the cooperative department and numerous complementary areas.

Industrial Education

William D. Wolansky, Head of Department

The Graduate Faculty

Members: Miller, Wolansky

Associate Members: Arcy, Beno, Gelina, McKay, McPherson, Parks, Riley, Sherick, Van Ast

The department offers work for the degrees Master of Science, Master of Education, and Doctor of Philosophy with major in industrial education, and minor work for students taking major work in other departments. Within the industrial education major, a student may specialize in industrial vocational-technical education, industrial education, or occupational and traffic safety education.

Prerequisite to major graduate work is preparation equivalent to the completion of the undergraduate curriculum in industrial education at Iowa State University and adequate proof that the student ranks above average in scholastic ability. The student must also possess adequate promise as a leader within the profession.

Though the department stipulates no foreign language requirement for either the Master of Science or Doctor of Philosophy degree, it may be relevant in individual cases to specify competence in one or more languages. Students not electing the thesis option, master's degree level, will be required to complete a minimum of 3 credits of a creative component project.

The department participates in the interdepartmental program in Technology and Social Change. (See Index.)

Course for Graduate Students, minor only

464. Aerospace Workshop for Educators. (2-2) Cr. 3. Aircraft, weather, navigation, and governmental regulations related to the fields of aerospace and aviation.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

Prior to registration for graduate level vocational certification courses, the student shall be classified as a senior or have an earned bachelor's degree, and be required to complete additional assigned readings, term papers, and graduate projects.

502. Applied Techniques in Materials and Processes. (2-4) Cr. 4. *Prereq: 10 credits in industrial education.* Classroom simulation of industry and study of the production process. Students participate in a profit-making corporate structure involving manufacture of hard goods. Exploration of management, systems, controls, financing and personnel.

528. Human and Public Relations for Industrial and Technical Education. (2-0) Cr. 2. *Prereq: IVTE 514.* Identifying a plan of public relations for industrial and technical education; analysis of publics that need to be reached; effect of human relations on public relations; criteria for evaluating public relations.

532. Industrial Arts and Technology for Children. (2-2) Cr. 3. *Prereq: 10 credits in elementary education or industrial education.* Development of elementary school programs in industrial arts. Identification of psychomotor and developmental factors in children related to tool and material manipulation. Integration of technology concepts into the elementary school curriculum. Use of industrial arts concepts to facilitate concept mastery in other disciplines.

550. Industrial and School Shop Safety. (3-0) Cr. 3. *Prereq: 310.* Safety as it pertains to the industrial arts and industrial vocational-technical teachers. OSHA and IOSHA regulations and the standards as required by OSHA and IOSHA.

554. History and Philosophy of Industrial Education. (3-0) Cr. 3. *Prereq: 312.* An evaluation of educational and industrial thought. Historical and philosophical development of industrial education to the present; trends and implications.

555. Administration and Supervision of Industrial Education. (3-0) Cr. 3. *Prereq: 417.* Administration, supervision, curriculum development, selection of staff, and public relations. Evaluating administrative and supervisory efforts; program modification. Field trips to schools and industries.

557. Organization and Management of the Industrial Education Laboratory. (3-0) Cr. 3. *Prereq: 410.* Principles and practices involved in the planning, organization, and management of the school shop; responsibilities of the school administrator and teacher; basic principles of planning; selection and purchase of machine tools, equipment and materials; maintenance, storage and control of machines, tools and equipment; managing the shop for effective work.

561. Advanced Topics in Power and Energy. (2-4) Cr. 4. *Prereq: 442.* Development of integrated systems utilizing fluids, electrical and mechanical components. Experimentation in alternative energy systems; system evaluation for efficiency and cost-effectiveness. Utilization of computers in real-time system monitoring and control of power and energy systems.

580. Advanced Topics in Graphic Communications. (2-4) Cr. 4. *Prereq: 425.* Exploration of computer graphics. Advanced design and drawing applications. Integration of aesthetic, function, cost, and human factors specifications in product design; evaluation of product design. Opportunity for individual creativity and specialization in an area of graphics.

581. Advanced Topics in Materials and Processes. (1-4) Cr. 3. *Prereq: 502.* Utilization of industrial materials including wood, metals, plastics, and ceramics, use of automation in manufacturing and quality control. Opportunity for specialization in the area of materials and processes.

590. Special Topics in Industrial Education. Cr. 1-4. *Prereq: Graduate classification in industrial education.* Special topics in industrial education administration, curriculum, evaluation, research, history, safety, technical education, etc.

593. Workshop in Industrial Education. Cr. 1 to 3. *Prereq: 15 credits in industrial education.*

599. Creative Problem. Cr. 1-3. A discipline-related problem to be identified and completed under the direction of the program adviser. Three credits required for all nonthesis master's degree students.

Courses for Graduate Students, major or minor

615. Seminar. Cr. 2-3. *Prereq: Credit or classification in 401.*

644. Futuristics in Industrial Education. (3-0) Cr. 3. *Prereq: Graduate classification, permission of instructor.* A critical analysis of industrial education in changing roles and requirements of education. Future alternatives for industrial education with relationship to society, education, and technology.

652. Program and Student Evaluation. (3-0) Cr. 3. *Prereq: 491.* Developing basic concepts of evaluation. Techniques for evaluating student personnel, facilities, programs, staff, and other educational resources.

653. Research and Development. (3-0) Cr. 3. *Prereq: Completion of master's degree and introductory statistics.* Examination of industrial R & D practices and procedures, product development standards, advanced product testing and research designs.

656. Instructional Materials for Industrial Education. (3-0) Cr. 3. *Prereq: Sec. Ed. 301 and 10 credits in industrial education.* Examination of new equipment, materials and techniques in using instructional materials in industrial education teaching.

657. Curriculum Development in Industrial Education. (3-0) Cr. 3. *Prereq: 15 credits in industrial education.* Basic concepts, trends, practices, and factors influencing curriculum development, techniques, organization and procedures; the course of study and its development in a given curriculum pattern.

699. Research. Arr. (3-14)

Industrial Vocational-Technical Education (IVTE)

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

510. Techniques of Teaching Vocational and Technical Education. (2-0) Cr. 2. *Prereq: 380.* Teaching processes, methods of presentation and testing, lesson planning, and organizational instruction.

514. Foundations of Vocational and Technical Education. (2-0) Cr. 2. *Prereq: Psych 333.* Development and philosophy of vocational-technical education, federal and state legislation. State plans, divisions, and types of programs.

519. Occupational Analysis and Course Construction. (2-0) Cr. 2. *Prereq: 510.* Course of study development based on occupational analysis. Compiliation, arrangement, and limitations of instructional materials.

522. Evaluation in Industrial Vocational-Technical Education. (2-0) Cr. 2. *Prereq: 510.* Theory and application of evaluation methods unique to vocational-technical educational programs.

524. Conference-Leading Techniques. (2-0) Cr. 2. *Prereq: 510.* Conference procedures and techniques as applied to teaching and advisory committee functions.

525. Coordination of Cooperative Education. (2-0) Cr. 2. *Prereq: 510.* Principles of organization, coordination, and administration of cooperative education with business and industry to provide part-time on-the-job training for students.

530. Administration and Leadership in Industrial Vocational-Technical Education. (3-0) Cr. 3. *Prereq: 514.* Administration and leadership styles, theory of administration, and applications to vocational-technical education.

536. Legislative and Financial Aspects of Industrial Vocational-Technical Education. (3-0) Cr. 3. *Prereq: 514.* Legislative and financial guidelines and practices at the local, state, and federal levels as they relate to secondary and post-secondary vocational programs, students, and staff.

549. Internship in Industrial Vocational-Technical Education. (arr.) Cr. 1-4. *Prereq: 10 hours in industrial education.* Emphasis on full experience in industrial vocational education as it relates to administration-supervision, special needs, curriculum-instruction, and evaluation-research.

590. Special Topics in Industrial Education. Cr. 1-5. *Prereq: Graduate classification in industrial education.*
A. Adult/IVTE
B. Vocational-Technical
C. Curriculum/IVTE
D. Evaluation/IVTE
E. Special Needs/IVTE
F. Instructional Materials/IVTE
G. Laboratory Problems/IVTE
I. Technical Training/IVTE
J. Administration

Safety Education and Driver Education (Saf)

Courses Primarily for Graduate Students, open to qualified undergraduates

500. Administration of Accident Prevention Programs. (3-0) Cr. 3. F. *Prereq: 315 or 317.* Procedures for organizing and administering an occupational and traffic safety education program.

515. Curriculum Development for Safety Programs. (3-0) Cr. 3. S. *Prereq: 315 or 415.* Theory and principles of content selection, methodology, and evaluative techniques applicable to traffic and occupational safety.

541. Safety Symposium. (1-0) Cr. 1. F. *Prereq: 9 hours in safety education.* A broad overview of the entire field of safety through outside readings by the classroom participants.

590. Special Topics in Safety Education. (Arr.) Cr. 1-3. Applications of safety education principles to special topics such as motorcycle, bicycle, industrial, household, traffic, etc. Individualized instruction in area of major interest and concentration.

593. Workshop in Occupational and/or Traffic Safety Education. Cr. 1-4. *Prereq: 15 credits in occupational and/or traffic safety education.*

599. Creative Component. Cr. 3. A discipline-related problem to be identified and completed under the direction of the program adviser. Three credits required for all nonthesis master's degree students.

Industrial Engineering

Keith L. McRoberts, Chair of Department

The Graduate Faculty

Members: Adams, Berger, Cowles, David, McRoberts, Malstrom, Montag, Moore, G. W. Smith, Walkup (Emeritus)

Associate Members: Barta, Classen, Even, Lamp, Meeks, C. E. Smith, Tamashunas, Vaughn

The department offers work leading to the degrees of Master of Engineering and Master of Science with majors in industrial engineering and engineering valuation, the degree of Doctor of Philosophy with major in engineering valuation, and minor work to students taking major work in other departments. Graduate work is designed to improve the student's ability in the professional practice of industrial engineering and to develop research capability.

The prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of undergraduate students in engineering at this institution.

With the help of a program of study committee, a graduate student designs an educational program in areas within industrial engineering and engineering valuation. Typical areas of concentration include engineering economics and capital budgeting; management science; management and regulation of public utilities; systems analysis and control; production systems analysis and design; human resources management; life analysis and depreciation; industrial property valuation; operations research and optimization; management information systems design; safety engineering; human factors engineering; and legal aspects of engineering administration. A specialization in operations research leading to a Master of Science degree is co-offered with the Department of Statistics.

The department also particiates in the following interdepartmental programs: Industrial Administrative Sciences, Industrial Relations, Energy Systems Engineering, Technology and Social Change and Transportation Planning. (See Index.)

Courses for Graduate Students, minor only

*304. Analysis for Engineering Economy. (2-0) Cr. 2. F.S. *Prereq: Junior classification and Com S 172.* Engineering/managerial analysis of the economic aspects of public and private project proposals. Decisions involving the expenditure of capital funds. Alternative sources of funds; time value of money; methods of evaluating alternative projects.

312. Industrial Operations Research. (4-0) Cr. 4. F.S. *Prereq: 209, 250, Math 266, credit or classification in Stat 231.* Concepts, analysis techniques, optimization techniques, and applications of operations research to industrial engineering. Construction and optimization of models for industrial systems using linear programming, queueing theory, and simulation. Use of problem-oriented languages such as MPS, GPSS, and FORTRAN in solving problems.

333. Computer Graphics. (2-0) Cr. 2 or 3. S. *Prereq: Com S 172 or 112.* Techniques for graphical man-machine communications. Use of available facilities. Graph plotting, two-dimensional and three-dimensional applications. Requirements and applications for interactive graphic communications. Individual projects. The optional third credit allows a project.

341. Material and Project Control. (3-0) Cr. 3. F.S. *Prereq: 312.* Analysis of inventory systems and sequencing and scheduling problems in the control of material flow with applications in industrial systems. Material requirement planning and project control techniques such as PERT and PERT/COST systems are included. Construction of mathematical models, use of heuristic techniques, and use of problem-oriented languages such as FORTRAN in solving problems. Project involving design of material control systems required.

361. Industrial Quality Control and Inspection. (3-0) Cr. 3. F.S. *Prereq: 250, Stat 231.* Techniques for obtaining measurements on industrial products and the statistical treatment of data to assure quality. Project involving the design of quality system.

374. Industrial Methodology. (2-0) Cr. 2. F.S. *Prereq. 250 or 375, M S E 271.* Analysis of industrial methods including fabrication, forming, cutting, welding, assembly inspection and finishing methods. Tooling methods including numerical and computer control of machines. Development of the manufacturing process from the economic aspect.

*375. Industrial Organization and Work Analysis. (3-0) Cr. 3. F.S. *Prereq: Junior Classification.* Industrial ownership, types of organizations. The principles and methods of production control, inspection, wage systems, cost control, with special emphasis on work analysis, methods and measurement.

*404. Engineering Economy. (3-0) Cr. 3. F.S. *Prereq: Econ 201, Acct 381.* Application of fundamentals of economics to engineering alternatives in planning, developing, and managing industrial projects.

407. Engineering Valuation. (3-0) Cr. 3. F.S. *Prereq: Econ 201, 2 credits in accounting.* Concepts of value, original cost, and reproduction cost, property records, methods of estimating depreciation for valuation and accounting; intangible values, cost values, earning values, rate base, and valuation for taxation, rates, financing, insurance, and sales.

421. Safety Engineering. (2-0) Cr. 2. F. *Prereq: 250 or 375.* Principles of hazard identification and accident prevention in the work environment. Hazards and their control to reduce risk of accident/illness. Incentives to provide a safe working environment including economic and legal aspects.

423. Industrial Compensation. (2-2) Cr. 3. F. *Prereq: 250 or 375.* Practices and procedures for designing and administering compensation systems utilizing job evaluation, performance rating, and wage survey. Incentive programs and employee benefit packages analyzed.

424. Human Resource Management. (1-2) Cr. 2. F.S.SS. *Prereq: 250 or 375.* Employer-employee problems and approaches to their solution utilizing behavioral science concepts. Emphasizes the organization, motivation, and management of human

resources, and principles and techniques of selection and placement, personnel development and evaluation, and union-management relations.

425. Socio-Technical System Design. (2-2) Cr. 3. F.S. *Prereq: 424.* Design of work systems recognizing socio-technical impact on job design, productivity, organization planning, and change. Emphasizes developing work environments concerned with quality of working life.

441. Industrial Engineering Design. (3-6) Cr. 5. F.S. *Prereq: 312, 373, 404.* Production planning and design of physical facilities for processing including site selection, material handling, equipment specification and layout, plant engineering and maintenance. Design of budgetary and cost controls for facility.

443. Industrial Materials Handling. (2-0) Cr. 2. F. *Prereq: 373, 312.* Analysis and application of mobile, fixed path, and semi-fixed path material handling equipment to industrial processes. Material handling relationships to packaging, warehousing, and physical distribution.

462. Industrial Systems Engineering. (3-0) Cr. 3. S. *Prereq: 209, Stat 231.* Application of mathematical and statistical techniques to the synthesis and analysis of industrial engineering problems. Use of computer methods for analyzing data and studying properties of industrial systems models.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

504. Advanced Engineering Economy. (3-0) Cr. 2 or 3. (3 cr. for students with 2 credits prerequisite and vice versa.) F.S. *Prereq: 304 or 404.* Advanced engineering economic analysis; engineering, financial, tax policy and other factors influencing managerial decisions involving the expenditure of capital funds.

505. Capital Expenditure Programming. (3-0) Cr. 3. S. *Prereq: 504.* Determination of capital expenditure policy and budget. Factors influencing the priority queue and the optimum-rationed level of expenditures. Project request, consideration, revision, screening, rejection, postponement, approval, subsequent verification and feedback processes. Planning and control of the capital expenditure budget and sources of funds.

506. Engineering Aspects of Public Utility Administration. (2-0) Cr. 2. F.S. *Prereq: 304 or 404, 407.* Engineering problems arising from the regulation of service and rates, the taxation, and the operation of public utilities.

507. Depreciation Estimates. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 407.* Collection and analysis of retirement data. Techniques required for the construction of survivor, probable life, condition percent, and accrued depreciation curves for property groups. Analysis of the effect of growing, declining, and stable properties on depreciation estimates.

509. Engineering Valuation Practice. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 407.* Application of principles of engineering valuation, including field work, preparation and pricing of inventories, valuations for utility rates, security regulations, condemnations, sales, estate settlements, and determining fixed capital costs.

511. Operations-Research Concepts. (4-0) Cr. 4. F. *Prereq: Math 267, Stat 231.* Theory and development of operations-research concepts and techniques within industrial contexts. Includes simplex method, networks, dynamic programming queueing theory, inventory theory, simulation, decision analysis, integer and nonlinear programming.

512. Queueing Theory and Applications. (2-0) Cr. 2. S. *Prereq: 312 or 511.* Development and use of mathematical models for the analysis of queueing systems. Applications to service industries as well as industrial types of situations. Steady state as well as transient systems are included.

514. Advanced Material Control. (3-0) Cr. 3. S. *Prereq: 341, 511, Stat 231 or 432.* Scheduling theory for project, flow, and shop systems including synthesis of production scheduling, analysis of the job shop problem, and application of network theory and queueing theory. Inventory systems, including both deterministic and stochastic lot size models, for single and multicommodity control of production materials. Constrained models. Computer analysis techniques.

515. Management Science (4-0) Cr. 4. S. *Prereq: 341 or 511.* Management science project including proposal preparation for industry or service problems. Final report on project for implementation of research results.

517. Design of Industrial Engineering Systems. (2-1) Cr. 3. F. *Prereq: 312 or 511, 404.* Application of feedback and dynamic concepts to industrial systems. Quantitative and simulation methods used to analyze and design effective systems for inventory, quality, scheduling etc., making efficient use of all productive resources.

518. Digital Simulation Techniques. (2-3) Cr. 3. F. *Prereq: Com S 172, Stat 231 or 432.* The simulation of mathematically indeterminate management and manufacturing systems by digital computer. Use of those optimization and statistical techniques that are helpful in simulation. Competence is developed in GPSS with an introduction to Simscript, GASP, and GERT.

527. Dynamics of Industrial Organizations. (2-2) Cr. 3. S. *Prereq: 424.* Advanced study of relevant current behavioral science research offering insight and understanding regarding the behavior of industrial organizations. Applications to the development of vibrant, viable, and socially effective work organizations.

531. Sequential Product and Process Control. (Stat 531). See *Statistics.*

533. Reliability. (Stat 533). See *Statistics.*

534. Mathematical Programming I. (4-0) Cr. 4. F. *Prereq: 511, Math 267.* Linear algebra, theory and computational aspects of simplex method. Duality treated theoretically and as a post optimality tool. Network and transportation problems. Unconstrained optimatization including convex and concave functions using descent methods and Quasi-Newton methods.

539. Game Theory. (Econ 539, Stat 539). See *Statistics.*

545. Advanced Facilities Design. (3-3) Cr. 4. Alt. F. offered 1982. *Prereq: 441.* Design of facilities to provide specific manufacturing services. Considerations and control applications for compuer aided manufacturing operations and industrial robots. Process sequence design for state-of-the-art manufacturing operations.

551. Industrial Engineering Concepts. (3-0) Cr. 3. F. *Prereq: 250 or 375, Stat 401, Math 151.* Development in depth of theoretical and practical concepts of current industrial engineering practice.

552. Industrial Organization Theory. (2-0) Cr. 2. S. *Prereq: 424, 551.* Theories of organization with the purpose of explaining, predicting, and influencing organization behavior. Requirements for design and control of industrial organizations and their components.

560. Industrial Information Systems. (3-0) Cr. 3. S. *Prereq: 209.* Role of information systems in supporting industrial operations such as manufacturing, personnel, resource allocation, scheduling, and forecasting. Design and usage of files. Economic and decision-process criteria in selection of hardware and software for industrial applications. Human factors in design of information systems.

571. Theory and Principles of Work-Time Relationships. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 375, 424.* Evaluation of work measurement systems considering repetitive and nonrepetitive stopwatch use, predetermined and developed standard data, and work sampling and operator log studies. Application to industrial situations. Analysis of current literature.

577. Human Factors. (2-2) Cr. 3. F. *Prereq: 274, Stat 231 or 401.* Physical and psychological factors affecting human performance. Emphasis on applications of human factors principles, measurement techniques, and analytical methods to practical design involving safety, productivity, stress reduction, behavioral control, and individual preferences. Laboratory work includes applications to current problems in system design and operation.

581. Administrative and Tax Law Aspects of Engineering. (3-0) Cr. 3. F. *Prereq: 480.* Administrative agencies, the administrative law that flows from these agencies, and its interrelationship with industry, with special emphasis on the substantive and administrative effects of taxation.

582. Intellectual Property and Product Liability Aspects of Engineering. (3-0) Cr. 3. S. *Prereq: 480.* To familiarize the prospective manager with problems encountered in the areas of patents, trademarks, copyrights, and product liability.

590. Special Topics. Cr. 1 to 5 each time elected. Independent study and work to explore recent advances and innovative approaches to industrial engineering design, practice, and research.
A. Valuation, Depreciation, and Engineering Economy
B. Human Resource Management
C. Industrial Engineering
D. Regulated Industries
E. Management Science and Operations Research

Courses for Graduate Students, major or minor

608. Depreciation Accountancy. (3-0) Cr. 3. Alt. S. offered 1982. *Prereq: 507.* Unit and group methods of accounting for depreciation; reserve requirements; adjustment of depreciation rates and reserves; classification of accounts, property accounting methods. Income tax regulations.

624. Advanced Human Resource Management. (2-2) Cr. 3. S. *Prereq: 425, 527 or 552.* Critical study and analysis of work design and organization structure for increase productivity. Application of behavioral sciences to design of work with concern for quality of working life. Legal and economic constraints included in analysis.

630. Mathematical Programming II. (4-0) Cr. 4. S. *Prereq: 534 or Stat 540.* Optimality conditions for nonlinear constrained problems. Primal methods, penalty and barrier methods. Integer programming including cutting planes, branch and bound and search enumeration plus specialized algorithms and applications.

651. Production System Philosophy. (2-0) Cr. 2. F. *Prereq: 511, 551.* An in-depth examination of the philosophy, nature, and assumptions inherent in cases and problems involving systems used to produce goods and services.

681. Court and Commission Practice. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 681A: 581, 608; 681B: 581.*
A. Utility rates, property valuation, and depreciation
B. Legal relations in industry

690. Advanced Topics. Cr. var.
A. Creative component for major in industrial engineering
B. Creative component for major in engineering valuation

691. Seminar. Cr. R. F.S.

699. Research. Cr. 1 to 5.
A. Industrial Engineering Research
B. Engineering Valuation Research

Industrial Relations

(Interdepartmental Program)

Paul M. Muchinsky, Chair, Supervisory Committee

Supervisory Committee: J. P. Mattila, R. P. Manatt, C. P. Morrow, C. E. Smith, J. M. Whitmer, W. F. Woodman

Work is offered for the degree Master of Science with a major in industrial relations. This is a multidisciplinary degree offered under a cooperative arrangement by the departments of Economics, Industrial Engineering, Political Science, Psychology, and Sociology.

Graduate students in industrial relations usually receive their undergraduate background in economics, business administration, industrial engineering, political science, psychology, or sociology. Admission is not restricted to students from these majors, however. Students entering industrial relations ideally should have a broad background in the social sciences.

The program in industrial relations is regarded as education for both professional practice and scientific inquiry. Through the Industrial Relations Center and its interdisciplinary faculty, facilities and opportunity exist for research of both a fundamental and applied nature on a variety of problems concerned with the world of people at work.

A student majoring in industrial relations will choose a major professor from the graduate faculty of the cooperating departments. The student's program of study will be developed with the guidance of an advisory committee selected by the student and the major professor, approved by the chairman of the Industrial Relations Supervisory Committee, and appointed by the dean of the Graduate College. Students may elect the thesis option (consisting of 30 semester-hour credits) or the nonthesis option (consisting of 36 semester-hour credits).

Regardless of which option is taken, all students must take the following core courses: Econ 445, I E 424, and Stat 401. For students enrolled in the non-thesis option, the research component of their degree program will be satisfied via the completion of a 3 credit creative component. For students enrolled in the thesis option, the research component of their degree program will be satisfied via the completion of a 6 credit thesis. The balance of the program of study for students in either option will consist of electives from the recommended courses in the industrial relations curriculum. A minimum of two courses must be taken in three of the five departments comprising the program, with a maximum of four courses in any one department. A minimum of 12 semester credits must be taken from 500-level (or above) courses. In general, the degree program in industrial relations is designed to be as flexible as possible to support the student's own professional interest. Satisfactory completion of a final comprehensive oral examination is required of all students. As part of their graduate education, students enrolled in the non-thesis program have the option of enrolling in an off-campus internship program.

Courses appropriate for the Master of Science degree are determined by the student's advisory committee. Recommended courses for graduate students majoring in industrial relations include: Econ 404, 445, 446, 590B, 595; I E 421, 423, 424, 527, 552, 590, 624; Pol S 420, 421, 425/525, 472, 475, 476/576, 571, 572, 573; Psych 425, 440, 450, 451, 550, 551, 590, 623; Soc 415, 420, 511, 532, 590B, 642; Stat 401, 402. See departmental listings for course descriptions and credits.

Institution Management

Marjorie M. McKinley, Head of Department

The Graduate Faculty

Member: Augustine (Emeritus), McKinley

Associate Members: Brown, Finley

The department offers work for the degree Master of Science with major in institution management and minor work to students taking major work in other departments.

Work may be taken for the degree Doctor of Philosophy as a joint major with departments offering work for this degree in home economics, engineering, economics, education, or other related areas.

The usual prerequisite to major graduate work is the completion of nine semester credits in institution management and six in food and nutrition, and fundamental preparation in accounting, chemistry, and microbiology. The exact requirements will depend upon the field of work the student expects to pursue.

Courses for Graduate Students, minor only

434. Food Purchasing. (2-2) Cr. 3. F.S. *Prereq: 380, 380L.* Principles of food procurement and inventory management for foodservice systems. Emphasis on specifications and factors affecting quality. Application of menu planning principles. Field trips required. Fee.

435. Layout and Equipment. (2-2) Cr. 3. F.S. *Prereq: Credit or classification in 380, 380L.* Food facilities planning and design; selection of equipment with emphasis on materials, construction, and specifications. Field trips required. Fee.

437. Automated Foodservice Information Systems. (2-0) Cr. 2. F.S. *Prereq: 434.* Application of computer-assisted management in foodservice organizations through the use of an educational simulation model. Interpretation of computer printouts with emphasis on use of data by management in planning and controlling functions.

438. Personnel Management in Institutions. (3-0) Cr. 3. F.S. *Prereq: Credit or classification in 380, 380L.* Functions of management. Principles of personnel organization and management as applied to foodservice and lodging systems. Principles and practices related to personnel recruitment, selection, training, employee-employer relations, and wage administration. Union and government considerations. Labor and cost control.

450. Hotel and Restaurant Accounting. (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 287, Acct 284.* Accounting procedures applicable to hotels, restaurants, and clubs. Emphasis on hotel front office and uniform systems of accounts. For students majoring in hotel and restaurant management.

460. Legal Aspects of Hotel and Restaurant Management. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: Mgmt 315.* Laws relating to ownership and operation of hotels, restaurants, and similar institutions. The responsibility of management and employees to guests and the public.

470. Quantity Food Production and Service Methods. Cr. arr. F.S.SS. *Prereq: A college course in principles of food preparation.* Methods of producing food in quantity using institution equipment. Interpretation for teaching nonsupervisory foodservice workers. Designed to contribute to preparation of teachers of vocational foodservice courses. Not accepted in lieu of I Mgt 380 and 380L for Iowa State institution management and food and nutrition majors.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Short Course. Cr. arr.

580. Quantity Food Development. (1-3) Cr. 2. S. *Prereq: 380 and 380L, advance reservation with department required.* Experimental approach to quantity food production. Development of formulas within parameters of time, institution equipment, and ingredients. Emphasis on sensory evaluation.

585. Catering. (1-3) Cr. 2. F. *Prereq: 380, 380L, advance reservation with department required.* Management, preparation, and presentation of special foodservice functions. Appreciation of historical and cultural background of U.S. regional and foreign foods. Creative experiences with gourmet foods.

590. Special Topics and Workshops. Cr. arr. *Prereq: Permission of department head.*
A. Foodservice Management
B. Housing Service Management
C. General

Courses for Graduate Students, major or minor

601. Decision Optimization in Institution Management. (4-0) Cr. 4. S. *Prereq: 6 semester credits in institution management including 437, college mathematics, statistics recommended, permission of department head.* Application of decision theory in institution foodservice and housing systems, using quantitative methods and models to optimize decisions. Use of computer as a tool for data analysis.

604. Seminar. Cr. arr. F.S.SS.

608. Administration Problems. Cr. arr. *Prereq: Permission of department head.* Consideration of advanced administrative problems. Case studies in foodservice and housing departments of Iowa State University, Memorial Union, and other establishments.

699. Research.

Journalism and Mass Communication

Robert S. Kahan, Chair of Department

The Graduate Faculty

Members: Hamilton, Hvistendahl, Schwartz, Shelley, Yarbrough

Associate Members: Abbott, Boyd, Crom, Emmerson, Gillette, Kielbowicz, Pollard, Scherer

The department offers the degree of master of science with major in journalism and mass communication, and minor work to students taking major work in other departments.

For major work, a student must have a bachelor's degree in journalism or in a subject matter area which he or she wishes to combine professionally with advanced training in journalism and mass communication.

Admission of international students is limited to applicants with two types of backgrounds: 1) those engaged in communication or development in such fields as agriculture, home economics, and natural resources in their own country and whose employment indicates a need for specialized training; 2) those who can document at least two years of professional journalism or the teaching of journalism and who wish to improve their professional capability.

Courses for Graduate Students, minor only

410. Mass Communication. (3-0) Cr. 3. F.S. *Prereq: 6 credits in social science.* Role of mass media; the scientific process; methods of measuring, evaluating and reporting media effects.

425. Impact of Communication Technology on People and Societies. (2-0) Cr. 2. F. *Prereq: Permission of instructor.* Seminar on present and potential effects of increasingly sophisticated modes of mass communication on people, institutions, and societies.

430. Law of Communication. (3-0) Cr. 3. F.S.SS. *Prereq: 6 credits in social science.* Defamation, privacy, sedition, obscenity, contempt, lottery, copyright, postal laws; the Federal Communications Act; laws affecting advertising, legal publication, and other business activities of the press.

431. Background of American Journalism. (3-0) Cr. 3. F.S. Role of the press in shaping the social, economic, and political history of America; impact of change in these areas on the development, traditions, and philosophies of the press.

438. Advertising and Public Relations Campaigns. (3-0) Cr. 3. S. *Prereq: 345.* Development of advertising and public relations campaigns for business and social institutions by projects involving budgeting media selection, market analysis, campaign strategy and practices in preparing the nucleus of a plans book.

440. International Communication and the Foreign Press. (3-0) Cr. 3. F. *Prereq: 6 credits in social science.* World communication systems, newsgathering and dissemination agencies, the role of foreign correspondents; factors determining flow and volume of world news. Comparative analysis of mass media. International political communication; role of U.S. media in world affairs.

450. Institutional Public Relations. (3-0) Cr. 3. F.S.SS. *Prereq: 6 credits in social science.* Public relations in business and other organizations, functions, process, and management; attitudes, public opinion and persuasion; tools of the public relations communicator; management of change in contemporary society.

462. Press Freedom, Responsibility, Ethics. (3-0) Cr. 3. F.S.SS. *Prereq: Permission of instructor.* Press ethics and performance; functions of the press in relation to the executive, judicial and legislative branches of government; agencies of press criticism; right to know versus right to privacy.

464. Journalism and Literature. (3-0) Cr. 3. F. *Prereq: Permission of instructor.* Writing as art as practiced by Twain, Hemingway, Crane, Dreiser, Whitman, Mencken, others; inquiry into the problems of the "New Journalism" as practiced by contemporary journalists.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501. Theories of Mass Communication. (3-3) Cr. 4. F. *Prereq: 6 credits in social science.* Examination of major areas of research activity and theoretic development related to organization, functions, and effects of mass communication.

502. Mass Communication Research. (3-3) Cr. 4. S. *Prereq: 501.* Applied research in broadcast and print media: survey research, audience and readership studies, readability, content analysis, media performance, experimental research, and sampling; theoretical research in systems theory, uses and gratifications theory, and the diffusion process as applied to the mass media.

515. Strategies of Communication. (1-2) Cr. 2. (3-0) S.SS. *Prereq: 6 credits in social science.* The process of developing professional communication and persuasion strategies, with emphasis on problem definition, behavioral specification of objectives, situation analysis, strategy formulation, and justification through application of communication theories and research results.

517. Visual Communication. (2-0) Cr. 2. S. *Prereq: Permission of instructor.* Exploration of aesthetic and social concepts in documentary still photography. Review of historical trends with emphasis on still photography as both an art form and as a means of social documentation.

526. Journalistic methods. (1-3) Cr. 2. F. *Prereq: Permission of instructor.* Reporting, writing and editing for the mass media. Designed for advanced students who have little or no background in journalism. Required of majors with minimum professional experience; *credits for majors will be in addition to the 30 required for graduation.*

527. Specialized Reporting. (1-4) Cr. 2. S. *Prereq: 526.* Reporting, writing, and editing for the communicator who mediates between scholar, scientist, and various publics.

528. Advanced Journalistic Methods. (2-4) Cr. 4. F. *Prereq: 501, 527.* Strategic planning and preparation of major communication programs including problem and audience analysis and the reporting, writing, editing and preparation of materials for appropriate media. Required of all majors except those in mass communication emphasis.

530. The Press and Society: Interrelationships. (3-0) Cr. 3. *Prereq: 6 credits in social science.* The press and its functions in a democratic society; conflicts between the press and social institutions; legal, social and political controls on the press; First Amendment theory.

545. Mass Communication in Developing Nations. (3-0) Cr. 3. S. *Prereq: 6 credits in social science.* Analysis of distribution of mass media in developing nations. Evaluation and comparison of traditional and transitional systems of communication in Africa, Asia and Latin America. Analysis of worldwide information flow. Role of communication in national development.

550. Television and Society. (2-0) Cr. 2. S. SS. *Prereq: Graduate classification, permission of instructor.* Examination of television's role in and impact on American society against historical background of its development and regulation. Contemporary evaluations of the medium's performance discussed in seminar format. Major paper required.

590. Special topics. Cr. arr. *Prereq: Permission of instructor.*
A. Broadcasting
B. Visual/Pictorial
C. Advertising
D. Media Management
E. Law
F. History
G. International
I. Audiences and Effects
K. Technology
L. Agricultural Journalism
M. Journalism Education
N. Home Economics Journalism
O. Public Relations

591. Professional Media Work. (0-6) Cr. 2. F.S.SS. *Prereq: 526.* Supervised internship experience on selected media. *Credits are to be applied in excess of the number required for graduation.* Required of graduate students with minimal professional experience.

650. Seminars in Journalism Communication. Cr. 2-3 each. Offered as demand warrants from following topic list.
A. Broadcasting
B. Visual/Pictorial
C. Television: Responsibility and Performance
D. Media Management
E. Communications Law
F. Communications History
G. International Communications
H. Society and Mass Communication
I. Audiences and Effects
M. Teaching Journalism and Mass Communication
N. Layout and Design of Publications
O. Book Production
P. Contemporary Problems
Q. Computer Applications
R. Visual Communication Research

699. Research.

Landscape Architecture

Albert J. Rutledge, Chair of Department

The Graduate Faculty

Member: Rutledge

Associate Members: Dyas, Harvey, Lane, Roberts, Sinatra

The department offers work for the degree Master of Landscape Architecture with major in landscape architecture. Minor work is offered to students taking major work in other departmentrs.

The degree Master of Landscape Architecture is granted upon the completion of two years of graduate study withha minimum of 40 credits in residence at Iowa State University. Satisfactory completion of L A 500, 541, 542, 643, 644, or their equivalents, and the acceptance of a thesis or a terminal project are required for the M.L.A. degree.

Students desiring to major in landscape architecture should present credits substantially equivalent to those secured by undergraduate students in the curriculum in landscape architecture at this institution. Students who cannot qualify with equivalent credits may be required to complete an additional year of study. The department also participates in the interdepartmental minor in Housing. (See *Index.)*

Courses for Graduate Students, minor only

361. Landscape Inventory and Analysis. (2-6) Cr. 4. F. *Prereq: 241.* Basic land use and natural resource data used in the landscape planning and design process. Review of data characteristics, landscape analysis techniques, and applications to site level and regional level problems. Identifying opportunities and limitation of landscape characteristics in planning and design for human use. Fee.

462. Landscape Evaluation. (1-9) Cr. 4. S. *Prereq: 342, 361.* Inventory, classification, and development of management objectives for visual components of landscapes. Techniques for interpreting and communicating this information. Legal and procedural precedents. Field trips. Fee.

463. Comprehensive Landscape Planning. (1-9) Cr. 4. F. *Prereq: 443, 462.* Physical design and arrangement of various land uses at regional and community scales. Design methodology and concepts communicated through graphic, written, and oral reports. Appliication of procedures which systematically analyze physical design impacts and define actions which could minimize the impacts. Field trips. Fee.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Seminar. (0-9) Cr. 3. F. *Prereq: 463.*

541. Studio Workshop I. (0-9) Cr. 3. F. *Prereq: 463.*

542. Studio Workshop II. (0-9) Cr. 3. S. *Prereq: 541.*

590. Special Topics. Cr. 1 to 4. F.S.SS. *Prereq: Permission of instructor.*
A. Landscape Design
B. Planting Design
C. Construction
D. History
E. Landscape Planning
F. Urban Design
G. Interdisciplinary Studies

Courses for Graduate Students, major or minor

643. Studio Workshop III. (0-9) Cr. 3. F. *Prereq: 542.*

644. Studio Workshop IV. (0-9) Cr. 3. S. *Prereq: 643.*

650. Terminal Project. Cr. Var. F.S.SS. *Prereq: Permission of major professor.* Comprehensive study and original development of a project selected by the student and approved by the department Completed project must be submitted to and approved by a graduate faculty committee as evidence of mastery of the principles of landscape architecture.

699. Research. Cr. Var. F.S.SS.

Library

Warren B. Kuhn, Head of Department

The Graduate Faculty

Member: Kuhn

The Library offers a series of non-credit seminars to assist graduate students in the effective use of the Library's research resources. The seminars cover general materials as well as more specialized ones in the broad areas of the biological and agricultural sciences, the engineering and physical sciences, and the humanities and social sciences. For information and registration consult the Library Reference Department. Offered F.S.SS.

Linguistics

See *English, Foreign Languages and Literatures,* and *Speech.*

Materials Science and Engineering

David R. Wilder, Chair of Department

The Graduate Faculty

Members: Berard, Carlson, Chen, Chiotti (Emeritus), Dodd, Gschneidner, Hunter, Kayser, Larsen, McGee, Patterson, Peterson, Rosauer, Scott, Smith, Spedding (Emeritus), Smyth, Trivedi, Verhoeven, Wechsler, Wilder, Wilhelm (Emeritus)

Associate Member: Martin

The department offers work for the degrees Master of Science (with thesis) and Doctor of Philosophy, with majors in ceramic engineering or metallurgy. Also offered is the Master of Engineering degree (without thesis), with a major in materials science and engineering as well as minor work to students taking major work in other departments. Students majoring in metallurgy may specialize in the areas of physical, chemical, and mechanical metallurrgy. Research in the department is closely associated with the Ames Laboratory of the U.S. Department of Energy and the Engineering Research Institute, which provide support for graduate student research assistantships.

Prerequisite to major graduate work is completion of an undergraduate curriculum in physical science or related engineering.

Before admission to candidacy for the degree Doctor of Philosophy with a major in metallurgy, the student is required to demonstrate proficiency in French, German, or Russian by attaining a score of 525 in the Educational Testing Service examination or obtaining a grade of B or better in Frnch 101 and 102; Ger 101 and 102; or Rus 101 and 102. After satisfying either of the above requirements, the student must translate one journal article per quarter for three consecutive quarters; the articles and translations are approved by the major professor.

There is no departmental foreign language requirement for students seeking the degree Doctor of Philosophy with a major in ceramic engineering. However, students are encouraged to include the study of a foreign language as a part of their program.

Because nuclear energy technology is an important application of materials, there is a cooperative arrangement with the Department of Nuclear Engineering. Students with majors in the Materials Science and Engineering Department interested in nuclear energy technology are encouraged to consider the following courses: Nuc E 401, 451, 471, 484, 535, 541, 582; M S E 375, 551, 552, 650.

The department participates in the Energy Systems Engineering minor program and the interdepartmental program of Technology and Social Change. (See Index)

Courses for Graduate Students, minor only

301, 302. Physical Metallurgy. (4-0) Cr. 4 each. Yr. *Prereq: 301: 231 or 270 or 271; 302: 301.* 301: Stereography, X-ray diffraction, basic dislocation theory, deformation of metals, grain boundaries, grain growth; vacancies, diffusion; 302: nucleation, solidification, recovery and recrystallization, solid solutions, precipitation hardening, twinning and martensite reactions, transformation kinetics, strengthening processes.

301L. Metallography Laboratory. (0-6) Cr. 2. F. *Prereq: Credit or classification in 301.* Preparation and analysis of ferrous and non-ferrous metals. Quantitative optical microscopy, scanning electron microscopy, powder X-ray diffraction, hardness testing.

302L. Physical Metallurgy Laboratory. (0-6) Cr. 2. S. *Prereq: Credit or classification in 302.* Experiments are carried out and analyzed which involve the following topics: Carburizing of steel, casting of bronze, brass and cast iron, Jominy end quench, induction hardening, x-ray and metallographic evaluation of retained austenite, age hardening of aluminum alloys, and welding of plain carbon and stainless steels.

321. Mechanical Behavior of Materials. (M E 321). See *Mechanical Engineering.*

322. Manufacturing Processes. (M E 322). See *Mechanical Engineering.*

337. Engineering Materials. (E M 337) See *Engineering Science and Mechanics.*

343. Electronic Ceramics. (3-0) Cr. 3. S. *Prereq: 231, Phys 222.* Underlying causes and characteristics of electrical and magnetic behavior of ceramic materials. Properties and production of common ceramic materials used for dielectric, optical, semiconductor, ionic conductor and magnetic applications.

344. Instruments for Materials Characterization. (2-6) Cr. 4. S. *Prereq: Phys 222.* Characterization of inorganic materials with information obtained from light microscopy, X-ray analysis, and electron beam instrumentation. Correlatioon with microstructures.

345. High Temperature Processes. (3-3) Cr. 4. S. *Prereq: 360 or Chem 321.* Use of high-temperature treatment to effect atomic transport and densification through sintering and vitrification. Prediction of final fired structure by means of phase equilibrium diagrams.

351, 352. Engineering Materials. (E Sci 351, 352). See *Engineering Science.*

360. Thermochemistry for Materials Science and Engineering. (3-0) Cr. 3. F. *Prereq: Chem 167 or 177, Math 266.* Basic laws of thermodynamics applied to materials systems. Thermodynamic properties of pure substances, homogeneous solutions, and dissolved components. Homogeneous and heterogeneous equilibrium. Property changes for chemical reactions.

361. Principles of Extractive Metallurgy. (3-3) Cr. 4. S. *Prereq: 360 or Chem 321.* Applications of chemical equilibrium, thermodynamics and reaction kinetics to the understanding of metallurgical unit operations. Introduction to diffusion, heat transfer and fluid flow principles and the utilization in extractive metallurgy processes.

370. Principles of Nondestructive Testing. (E M 370). (3-0) Cr. 3. S. *Prereq: Phys 112 or 222.* Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection and other less common techniques. Physical bases of test; materials to which applicable; types of defects detectable; calibration standards, and reliability; safety precautions.

370L. Nondestructive Testing Laboratory. (E M 370L). (0-3) Cr. I. S. *Prereq: Credit or classification in 370.* Application of non-destructive testing techniques to detection of flaws in materials.

375. Nuclear Materials and Radiation Effects. (3-0) Cr. 3. F. *Prereq: 231 or 270 or 271.* Materials for fission and fusion reactors. Radiation flux and spectrum, collision dynamics, and defects in materials. Displacement radiation damage and transmutations. Defect clusters, voids, and bubbles, and effects on mechanical properties. Fuel, cladding, control, core structure, pressure vessel, shielding, and balance-of-plant materials. Current materials topics in nuclear technology.

401, 402. Mechanical Metallurgy. (3-0) Cr. 3 each. F.S. *Prereq: 401: 302, E M 324; 402: 401.* 401. Stress-strain, elastic and plastic deformation, testing methods and principles, creep and stress rupture, strengthening mechanisms. 402. Fracture mechanics, metal forming processes, failure analysis, codes and standards.

402L. Mechanical Metallurgy Laboratory. (0-6) Cr. 2. F. *Prereq: Credit or classification in 402.* Tension and impact testing, residual stresses, creep, stress rupture and fatigue tests.

410. Physical Metallurgy. (3-0) Cr. 3. F. *Prereq: Chem 167 or 177, Math 266.* Introduction to physical metallurgy for seniors or graduate students in science or engineering who have little or no prior preparation in metallurgy. Not acceptable for credit for students in metallurgy or metallurgical engineering.

440. Mechanical and Thermal Properties of Ceramic Materials. (3-0) Cr. 3. F. *Prereq: E M 324.* Fundamentals of mechanical and thermal behavior of ceramic materials. Properties and production of common ceramic materials used for mechanical and thermal applications.

441. Refractories. (3-0) Cr. 3. F. *Prereq: 360, 302 or 345.* Mineralogy, manufacture and service characteristics of fireclay, high alumina, silica, basic and carbon refractories. Use of refractories in metallurgical and ceramic industries.

442. Vitreous State. (3-3) Cr. 4. S. *Prereq: Chem 167.* Theory of the vitreous state. Structure and properties of inorganic glasses, melting, forming and annealing methods. Application of vitreous coatings to metal.

445, 446. Ceramic Engineering Design. 445 (2-3) Cr. 3. 446 (1-3) Cr. 2. Yr. *Prereq: 445: 330, 345, Phys 222; 446: 445.* 445: Design and analysis of furnaces. 446: Design, analysis, implementation and demonstration of a ceramic process.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

501. Thermodynamics of Physico-chemical Processes in Solids. (3-0) Cr. 3. F. *Prereq: 301 or 345, 360, or Chem 321, Math 266.* Review of basic principles, thermodynamic potentials, stability principles, effects of strain energy, solution thermodynamics, free-energy-composition diagrams, and thermodynamic driving forces. Nucleation and spinodal decomposition theory. Solidification.

502. Diffusion in Metals and Kinetics of Physical Metallurgical Reactions. (3-0) Cr. 3. S. *Prereq: 501.* Mechanism of diffusion. Phenomenological aspects. Diffusion applied to kinetic processes. Anelasticity. Precipitation and segregation reactions. Recovery and recrystallization. Order-disorder reactions. Displacive transformations.

503. Mechanical Behavior of Materials. (3-0) Cr. 3. F. *Prereq: Phys 222, Math 266.* Mechanical behavior of materials based on an atomic and microstructural viewpoint. Stress and strain, dislocation mechanics, plasticity, yield criteria. Stress and strain concentrations. Brittle and ductile fracture, statistical aspects of fracture, McClintock hole growth model. Thermal fracture. Fatigue and creep.

512. Introductory Metal Theory. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: Phys 222, Math 266.* Free electron theory and band theory. Brillouin zones and Fermi surfaces, electronic conductivity and scattering processes, electronic heat capacities, and comparison of metals to semiconductors.

513. Advanced Extractive Metallurgy. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 360 or Chem 321.* Occurrence and production of metals, including the less common metals. Analysis of economic, stoichiometric, and thermodynamic principles in chemical metallurgy.

514. Applications of Metallurgical Thermodynamics. (2-0) Cr. 2. S. *Prereq: 501.* Solubility of gases in metals, oxidation of metals and alloys, thermochemistry of steelmaking, atmosphere control with gas mixtures, special applications of Clausius-Clapeyron equation, use of Richardson-Jeffes charts, thermodynamics of alloys.

518. Magnetism and Metallurgy of Magnetic Materials. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: Math 266.* Physical and metallurgial principles of soft and hard magnetic substances including ferrites, thin films, and fine particles. Major applications of ferromagnetic materials.

520. Chemical and Physical Metallurgy of Rare Earths. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 302 or 410 or Phys 325, 360 or Chem 321.* Electronic configuration, valence states, minerals, ores, beneficiation, extraction, separation, metal preparation and purification, crystal structure, transformation, melting and boiling points, chemical behavior, inorganic compounds, alloy chemistry, nature of the chemical bond, mechanical and elastic properties, magnetic properties, resistivity, and superconductivity.

521. Properties of High Polymers. (M E 521). See *Mechanical Engineering.*

522. Structure, Properties and Heat Treatment of Ferrous and Non-ferrous Alloys. (3-0) Cr. 3. F. *Prereq: 302 or 331 or 410.* Application of fundamental concepts of phase transformations, heat flow, mechanical behavior, and structure-property relations to the problems of heat treatment and selection of steels and aluminum, copper and titanium alloys.

523. Corrosion and Oxidation. (2-0) Cr. 2. F. *Prereq: 360 or Chem 321.* Study of origin, development, and current applicability of theories of corrosion and oxidation of metals.

524. Casting and Welding of Metals. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 301 or 344 or 410.* Dendritic growth and control of macrostructure in castings, ingots, and continuous cast metals. Porosity and its control. Riser and gating design. Mechanical properties of cast metals. Welding characteristics of steels and important non-ferrous alloys.

525. X-Ray Diffraction. (3-0) Cr. 3. S. *Prereq: 301 or 344 or 410.* Introduction to theory of x-ray and neutron diffraction, symmetry operations, space groups and reciprocal lattice. Laue and power diffraction methods and their application to precise lattice parameters, determination of simple crystal structures, phase identification, orientation, texture, grain size, strain, residual stress and order-disorder. Chemical analysis by x-ray method and small angle scattering.

551. Radiation Effects on Materials I: Fundamental Radiation Damage. (Nuc E 551) (3-0) Cr. 3. F. *Prereq: 270 or 271 or 375.* Characteristics of radiation environments. Scattering and absorption cross sections. Determination of neutron flux and spectrum. Defects in materials. Experimental observations of radiation damage. Effects of annealing and impurities.

552. Radiation Effects on Materials II: Application to Nuclear Systems. (Nuc E 552) (3-0) Cr. 3. S. *Prereq: 551.* Defect clusters, voids, and bubbles. Radiation hardening and embrittlement. Radiation effects on pressure vessel steels, fuel cladding, and core components. Radiation-induced swelling. Fuel restructuring and densification. Radiation effects on materials for fusion reactors. Radiation effects on non-metals, including semiconductors and polymers.

560. Scanning Electron Microscopy Characterization of Materials. (E M 560). See *Engineering Science and Mechanics.*

564. Fracture and Fatigue. (E M 564). See *Engineering Science and Mechanics.*

568. Plasticity and Creep of Materials. (E M 568). See *Engineering Science and Mechanics.*

569. Mechanics of Composite and Combined Materials. (E M 569). See *Engineering Science and Mechanics.*

570. Equilibrium and Nonequilibrium Ceramic Systems. (3-0) Cr. 3. Offered as arr. *Prereq: 345.* Review of classicial thermodynamics, introduction to irreversible thermodynamicis, driving forces, rate process theory, and phase equilibria in ceramic systems.

571. Ideal and Defect-Containing Crystalline Compounds. (3-0) Cr. 3. Offered as arr. *Prereq: 231 or 270, 345.* Crystal chemistry of oxides and other inorganic compounds. Crystal structure-property relationships for ideal structures and structures containing point defects such as Schottky and Frenkel defects plus defects created by non-stoichiometry and doping.

573. Measurements in High Temperature Systems. (2-0) Cr. 2. Offered as arr. *Prereq: 360 or Chem 321.* Theory, limitations and problems of analysis of measurements at elevated temperature. Furnaces and techniques for determination of mechanical, physical, structural, and chemical properties of ceramics at elevated temperatures.

575. Vitreous State. (3-0) Cr. 3. Offered as arr. *Prereq: 442 or 360 or Chem 321.* Advanced theory of the vitreous state. Structure of glasses, nucleation theory, control of devitrification, composition-structure property relationships.

580. Biomaterials. (E M 580, B M E 580). See *Engineering Science and Mechanics.*

585. Electron Microscopy of Inorganic Materials. (2-3) Cr. 3. Offered as arr. *Prereq: Phys 222.* Microstructural and compositional characterization of materials by transmission electron microscopy, scanning electron microscopy, and electron microprobe analysis. Energy and wavelength elemental analysis and various electron diffraction modes. Specimen preparation methods. Intensive hands-on laboratory.

590. Special Topics. Cr. Var. *Prereq: Permission of instructor.*
A. Metallurgy
B. Ceramics

595. Topics in Material Science. Cr. 1 to 3 each time elected. Arr. *Prereq: Permission of instructor.*
A. Electronic Ceramics
B. Refractories
C. Colloids
D. X-ray Diffraction Laboratory
E. Microstructural Studies
F. Mechanical properties of Ceramic Materials

Courses for Graduate Students, major or minor

601. Transport in Solids. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 501 or 570.* Heat and mass transport in solids developed in terms of mathematical concepts. Mathematical analysis of applied problems involving heat and mass transport in solid materials. Atomistic description of diffusion in solids. Stochastic aspects of atomic and ionic diffusion. Phenomenological formulation of mass transport with applications to kinetic processes at elevated temperatures. Experimental methods employed in solid state diffusion studies.

602. Martensitic Phase Transformation and Twinning. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 502.* Thermodynamic and crystallographic aspects of martensitic transformations. Nucleation of martensite. Diffusion-related and diffusionless characteristics. Matrix algebraic analysis of shear transformations and twinning. Phenomenological theories of martensite formation; shape change, habit plane, and orientation relationships. Stress-assisted martensite formation. Shape memory alloys; application to heat engines and other devices.

604. Transmission and Scanning - Transmission Electron Microscopy of Thin Crystals. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 302 or 410.* TEM and STEM and their application to observation of dislocations, voids and bubbles, precipitates, stacking faults, and magnetic and antiphase domain boundaries. Selected-area and microdiffraction.

605. Dislocation Theory and Applications. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 503.* Stress, strain, and displacement fields associated with dislocations. Self stress considerations of curved dislocations and line tension. Self energy of dislocation loops and their stability. Details of dislocation interaction with various barriers and calculations of associated force-distance curves. Applications to strengthening mechanisms.

650. Nuclear Reactor Fuels. (Nuc E 650). (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 375 or 552.* Physical, chemical, nuclear, thermal, and mechanical properties of metallic, ceramic, and liquid fuels for nuclear reactors. Fuel cycles and fuel element design in thermal and fast reactors. Fuel fabrication. Behavior of fission products. Fuel restructuring and densification. Implications for safety and economics of nuclear reactors.

670. Kinetics of Ceramic Processes. (3-0) Cr. 3. *Prereq: 570, 571.* Reaction rate theory and concepts of diffusion in ionic materials applied to analysis of important ceramic processes. Solid state and gas-solid reactions, sintering, grain growth and polymorphic transformations.

690. Advanced Topics. Cr. Var. *Prereq: Permission of instructor.*
A. Creative Component
B. Other

695. Advanced Topics in Material Science. Cr. 1 to 3 each time elected.
A. X-ray Scattering From Crystals
B. Alloy Theory
C. Metallurgical Thermodynamics

699. Research.

Mathematics

Wilfred E. Barnes, Head of Department

The Graduate Faculty

Members: Abian, Athreya, Barnes, Cain, Carlson, Colwell, Cornette, Corones, Dahiya, Dickson, Fink, Gregorac, Heimes, Hentzel, Isaacson, Keller, Kim, Lambert, Levine, Luecke, Madych, Maple, Mathews, Miller, Murdock, Peters, Pigozzi, Sanderson, Seifert, Smith, A. K. Steiner, E. F. Steiner, Tondra, Triggiani, Vinograde (Emeritus), Weiss, Willson, Wright.

Associate Members: Abatzoglou, Epstein, Hogben, Homer, Kegley, Lindahl (Emeritus), Maddux, Meany, Nelson, Peake, Peglar, Rudolph, Sprague

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in mathematics or applied mathematics, and minor work to students taking major work in other departments.

Students desiring to do graduate work with a major in this department should present at least 12 semester credits of work in mathematics beyond calculus. It is desirable that this include advanced calculus and abstract algebra.

The M.S. degree may be taken either with or without thesis. Candidates for the M.S. and Ph.D. degrees must pass a written comprehensive examination covering basic graduate work. Ability to use two foreign languages (normally chosen from French, German, and Russian) as effective research tools in the student's area of specialization is required for the Ph.D.

Master of Science candidates must have one year and Doctor of Philosophy candidates must have two years of supervised teaching experience. These minima are subject to increase in individual cases upon recommendation of the student's program of study committee and approval of the department head.

Courses for Graduate Students, minor only

301, 302. Introduction to Abstract Algebra. (3-0) Cr. 3 each. Yr. *Prereq: 301: 166 or 176; 302: 301 and one of 266, 267, 270, 307.* 301: Introduction to the theory of groups and rings. 302: Theory of fields, abstract vector spaces, and linear algebra.

304. Introductory Combinatorics and Discrete Probability. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 166 or 176.* Permutations, combinations, binomial coefficients, inclusion-exclusion principle, discrete probability, classical probability. Additional topics selected from recurrence relations, generating functions, random walks, and Markov chains.

307. Theory of Matrices. (3-0) Cr. 3. F.S.SS. *Prereq: 1 semester of calculus.* The algebra of matrices including vector spaces, simultaneous linear equations, determinants, quadratic forms, eigenvalues, and diagonalization over the real and complex numbers.

308. Application of Linear Algebra to Discrete Optimization. (3-0) Cr. 3. S. *Prereq: 270 or 302 or 307.* Linear programming and topics chosen from game theory, transportation and assignment problems, discrete dynamic processes, and multiple objective linear programming.

331, 332. Topology. (3-0) Cr. 3 each. Yr. *Prereq: 331: 265 or 270; 332: 331.* Topological properties of metric spaces with emphasis on R^n, sequences, continuous functions, completeness, compactness. Abstract topological spaces and related properties, including compactifications, connectedness and fundamental groups.

365. Complex Variables with Applications. (3-0) Cr. 3. F.S. *Prereq: 265 or 371.* Functions of a complex variable, including differentiation, integration and series expansions, residues, evaluation of integrals, conformal mapping.

385. Introduction to Partial Differential Equations. (3-0) Cr. 3. F.S.SS. *Prereq: 371; or 265 and one of 266, 267.* Fourier series, separation of variable methods, Bessel series and Legendre polynomials, introduction to Sturm-Liouville theory.

414, 415. Advanced Calculus. (3-0) Cr. 3 each. Yr. *Prereq: 371; or 265 and 307.* 414: A careful development of calculus of functions of a real variable: limits, continuity, differentiation, integration, series. 415: Calculus of functions from R^n to R^m, linear and topological properties of R^n, limits, continuity, differentiation, implicit functions, multiple integrals, line and surface integrals, Stokes' theorem.

421. Mathematical Logic. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 201 or 301.* Validity, consistency, provability, completeness, definability, and decision problems for propositional calculus, predicate calculus, and generalized mathematical theories.

426. Mathematical Methods for the Physical Sciences. (3-0) Cr. 3. F. *Prereq: 385.* Primarily for first-year graduate students in physics and chemistry. (Not a substitute for Math 526-527.) Techniques presented provide students with mathematical background needed for study of electrodynamics, statistical mechanics, and quantum mechanics. Emphasis on technique rather than theory. Boundary value problems, contour integration and conformal mapping, spinors, matrix eigenvalue problems, introduction to integral equations and Green's functions.

435, 436. Geometry. (3-0) Cr. 3 each. Yr. *Prereq: 435: 270 or 307; 436: 435.* Euclidean geometry through properties invariant under similarity transformations, projective geometry by use of synthetic and analytic methods, topics chosen from finite geometry, non-Euclidean geometry and crystallography.

450. Number Theory. (3-0) Cr. 3 Alt. S., offered 1983. *Prereq: 301.* Properties of the integers. Diophantine equations, prime number distribution and representation problems.

465. Advanced Calculus for Applied Mathematics. (4-0) Cr. 4. F.S.SS. *Prereq: 265 or 371.* Certain frequently applied mathematical concepts presented with enough theory to promote understanding of applications. Calculus of functions of several variables, including vector calculus, line, surface, and multiple integrals, Stokes' theorem, divergence theorem, infinite series.

471. Computational Linear Algebra and Fixed Point Iteration. (Com S 471) (3-0) Cr. 3. F.S.SS. *Prereq: 270; or 265 and one of 266, 267; knowledge of FORTRAN.* Computational error, solutions of linear systems, least square methods, similarity methods for eigenvalues, non-linear equations, fixed point iteration in one and several variables, Newton's method in several variables.

481. Numerical Solution of Differential Equations and Interpolation. (Com S 481) (3-0) Cr. 3. F.S. *Prereq: 371; or 265 and one of 266, 267; knowledge of FORTRAN.* Orthogonal polynomials, least square and spline methods, numerical differentiation and integration, Euler, Taylor, Runge-Kutta, and predictor-corrector methods for solution of systems of ordinary differential equations.

489. History of Mathematics. (3-0) Cr. 3. S. *Prereq: Some knowledge of geometry and calculus recommended.* Development of mathematical ideas through the eighteenth century, with some emphasis on primary sources.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

504, 505. Abstract Algebra. (3-0) Cr. 3 each. Yr. *Prereq: 302.* Algebraic systems and their morphisms, including groups, rings, and linear algebra.

507. Numerical Solution of Ordinary Differential Equations. (Com S 507) (3-0) Cr. 3. F. *Prereq: 481 or 465 or 415; knowledge of FORTRAN.* One step methods for initial value problems, one-step methods for systems, multistep methods, boundary-value problems. Examples using university computers.

509. Computational Methods of Linear Algebra. (Com S 509) (3-0) Cr. 3. S. *Prereq: 270 or 302 or 307; knowledge of FORTRAN.* Numerical methods involved in the solution of linear systems, matrix inversion, eigenvalue problems (symmetric and nonsymmetric); completion method, ill-conditioned matrices, linear inequalities. Examples using university computers.

510. Linear Algebra. (3-0) Cr. 3 F. *Prereq: 302 or 307.* Brief review of elementary linear algebra, followed by advanced topics; canonical forms, inner product spaces, bilinear forms, tensor products, and applications to other branches of mathematics.

511, 512. Functions of a Single Complex Variable. (3-0) Cr. 3 each. 511: F.SS.; 512: S. *Prereq: 465 or 415.* Topological concepts for extended complex plane, analytic functions, conformal mappings, integration, power series, Laurent series, Cauchy residue theorem, evaluation of real integrals, harmonic functions, analytic continuation.

514, 515. Real Analysis. (3-0) Cr. 3 each. Yr. *Prereq: 415.* Basic concepts of topological spaces, function spaces, measure and integration.

521, 522. Applied Mathematics. (3-0) Cr. 3 each. 521: F.SS.; 522: S. *Prereq: 521: 365, 385; 522: 521.* 521: Solution methods for classical linear partial differential equations. Series methods, Laplace and Fourier transforms, Green's functions, and other techniques. 522: Approximate solutions to partial differential equations; emphasis on the finite element method.

524. Theory of Automata. (3-0) Cr. 3. S. *Prereq: 301.* Combinatorial theory of automata: various mathematical models of computation and their comparison; finite state machines. Turing machines, the halting problem. Algebraic theory of automata: structure of finite transition algebras and semigroups.

526, 527. Mathematics of Classical and Quantum Physics. (3-0) Cr. 3 each. Yr. *Prereq: 365 or 426, 385.* Linear operators on finite and infinite dimensional vector spaces. Eigenvectors, diagonalization, Hilbert space, orthogonal series, analytic functions, Green's functions, integral equations.

528, 529. Special Functions. (3-0) Cr. 3 each. Yr. *Prereq: 365.* Gamma and beta functions, classical polynomials, Legendre and Bessel functions, elliptic integrals, and other functions of hypergeometric type. A unified treatment of the special functions arising in applied mathematics.

531, 532. Introduction to Functional Analysis. (3-0) Cr. 3 each. Alt. Yr., offered 1981-82. *Prereq: Permission of instructor.* Fundamental theory of normed linear spaces and algebras emphasizing aspects that provide a framework for study of boundary-value problems, eigenvalue problems, harmonic analysis, and analytic function theory. Hahn-Banach theorem, Banach-Steinhaus theorem, Gelfand representation, elementary spectral theory for operators in Hilbert space.

534, 535. Topology. (3-0) Cr. 3 each. Yr. *Prereq: Permission of instructor.* Introduction to general topology and homotopy theory.

537, 538. Algebraic Topology. (3-0) Cr. 3 each. Alt. Yr., offered 1982-83. *Prereq: 302, 332.* Foundations of algebraic topology. Homotopy and homology groups, fibrations, applications to manifolds.

554. Probability. (Stat 554) (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: Stat 542.* Occupancy problems, generating functions, compound distributions, recurrent events, characterizations of discrete distributions, urn models with applications.

555. Stochastic Processes. (Stat 555) (3-0) Cr. 3. S. *Prereq: Stat 542.* Basic theory and applications of stochastic processes including the Poisson process, the Wiener process, discrete-time stationary and nonstationary Markov chains, and continuous-time Markov chains.

557, 558. Ordinary Differential Equations. (3-0) Cr. 3 each. Yr. *Prereq: 266 or 267 or 371; 270 or 302 or 307; 415 or 465.* The initial-value problem, existence and uniqueness theorems, linear systems, stability and asymptotic behavior of solutions, dynamical systems, two-point boundary-value problems.

562. Tensor Analysis and Manifolds. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: Permission of instructor.* Coordinate systems and transformations, differential forms, Riemannian metrics. covariant differentiation, curvature tensors, geometry of surfaces in Euclidean space.

564. Theory of Groups. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 505.* Commutators, p-groups, nilpotent groups, solvable groups, permutation groups, free groups, semidirect products, introduction to representation theory.

567. Boolean Rings. (3-0) Cr. 3. SS. *Prereq: Permission of instructor.* Structure of semisimple commutative rings and their representations. Atomicity and completeness. Stone space of Boolean rings. The field of Borel and Baire sets. Theorems on extension of homomorphisms. Application to mathematical logic and measure theory.

568. Theory of Rings. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 505.* Selected topics from the structure theory for various classes of rings, including the theory of radicals and rings with chain conditions.

571, 572. Mathematical Logic. (3-0) Cr. 3 each. Alt. Yr., offered 1981-82. *Prereq: 421.* Algebraic structures in logical systems, recursive functions, consistency, undecidability and incompleteness of axiomatic theories, results of Gentzen and Godel, theory of models, ultraproducts and ultralimits, nonstandard analysis.

581, 582. Axiomatic Set Theory. (3-0) Cr. 3 each. Yr. *Prereq: Permission of instructor.* Axiomatic considerations, model and proof theory, Zermelo-Fraenkel axioms, classical theorems, transfinite methods, ordinal and cardinal numbers and their arithmetic. Von Neumann-Bernays-Godel axioms, inaccessible cardinals, consistency and independence results of Godel, Cohen, and others, method of Forcing.

584. Category Theory. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 302.* Categories and functors and their applications.

585, 586. Partial Differential Equations. (3-0) Cr. 3 each. Alt. Yr., offered 1981-82. *Prereq: 415 or 521 or 526.* First order equations and systems; wave, heat and potential equations, Huygen's principle, fundamental solutions; maximum principle; variational methods.

590. Special topics. Cr. var.

Courses for Graduate students, major or minor

610. Seminar.

690. Advanced Topics. Cr. var. *Prereq: Permission of instructor.*

A. Algebra
B. Functional Analysis
C. Measure Theory
D. Approximation Theory
E. Linear Algebra
F. Calculus of Variations
H. Harmonic Analysis
L. Logic and Foundations
M. Complex Analysis
N. Numerical Analysis
O. Ordinary Differential Equations
P. Partial Differential Equations
S. Set Theory
T. Topology
U. Automata Theory
V. Optimization Theory

699. Research.

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[a] Either 104 or 150 may be counted toward graduation, but not both.

[b] Both of the sequences 165, 166, 265, 266 or 267 and 175, 176, 270, 371 will prepare a student for further study in 300-400 level mathematics courses. The main differences are that the 175, 176, 270, 371 sequence moves at a faster pace, introduces differential equations earlier, and places more emphasis on the use of linear mathematics. Credit for courses from both sequences, which contain a large amount of similar material, may not count toward graduation.

[c] No more than 3 credits of 141, 142 may count toward graduation.

[d] Only one of the 165-166, 175-176 sequences or 151 or 160 may be counted toward graduation.

Mechanical Engineering

Arthur E. Bergles, Chair of Department

The Graduate Faculty

Members: Bahadur, Baumgarten, Bergles, Black, Cook, Hall, Junkhan, Kavanagh, Mischke, Okiishi, Pletcher, Serovy, Wilson, Woods

Associate Members: Colver, Fellinger, Henkin, Joensen, Kuehn, Peters, Shapiro

The department offers work for the degrees Master of Science, and Doctor of Philosophy with major in mechanical engineering, and minor work to students taking major work in other departments. Course offerings may be used in co-major or minor programs for students of other departments.

At the time of admission graduate students who have not completed an undergraduate program of study substantially equivalent to that required of undergraduate students in the department can expect that additional supporting course

work, as determined by their program of study committee, will be required.

The graduate program emphasizes advanced study, including design and research, in such areas as fluid mechanics and turbomachinery, fluid power and controls, heat transfer, machines and systems, materials and manufacturing processes, and thermodynamics and energy utilization. Instrumentation and design of experiments are applied to all of these areas. Reliability, computational, dynamic, environmental, materials, and legal considerations in design are emphasized.

The department participates in the interdepartmental minor program of Energy Systems Engineering (See Index.)

The department encourages students to broaden their education by participating in minor programs in established departments, interdepartmental programs, or such other experiences as approved by their program of study committees.

The requirements for advanced degrees are established by the student's program of study committee. A foreign language requirement exists only for the degree Doctor of Philosophy when the student's program of study committee deems it appropriate to a specific program of study. It is possible to arrange a program of study for the Master of Science on a nonthesis basis.

Courses for Graduate Students, minor only

310. Mechanisms. (3-0) Cr. 3. F.S.SS. *Prereq: 253, E M 345.* The design problem and the role of interactive computing. Theory of machines, kinematic and dynamic analysis of mechanisms. Synthesis methods.

311. Mechanical Systems. (2-2) Cr. 3. F.S. *Prereq: 310, Math 267, E E 441.* Mechanical systems, their equations of motion and dynamic response. Fundamentals of industrial automatic control. Laboratory experiments and problems.

312. Design of Machine Elements. (3-0) Cr. 3. F.S.SS. *Prereq: 310, 321.* Philosophy of design. Failure models useful in fatigue and distortion circumstances. Analysis, selection and synthesis of machine elements.

321. Mechanical Behavior of Materials. (MSE 321) (2-2) Cr. 3. F.S.SS. *Prereq: M S E 270, E M 324.* Application of the basic principles of structure of solids to the study and control of mechanical properties. Qualitative and quantitative relationships between microstructure and mechanical properties.

322. Manufacturing Processes. (2-2) Cr. 3. F.S.SS. *Prereq: 321.* The relationship between material properties, manufacturing processes, and product properties. The basic processes (casting, welding, forming, and machining) and the functional characteristics of equipment. Manufacturing considerations in design.

***331. Engineering Thermodynamics I.** (4-0) Cr. 4. F.S. *Prereq: Math 265, Phys 222, junior classification.* Fundamental concepts based on zeroth, first and second laws of thermodynamics. Properties and processes for ideal gases and solid-liquid-vapor phases of pure substances. Vapor cycles for power and refrigeration. Constant composition gas mixtures. Psychrometry and introduction to air conditioning processes.

332. Engineering Thermodynamics II. (3-0) Cr. 3. F.S. *Prereq: 331.* Air tables, one-dimensional compressible flow. Compressors and turbines. Air standard cycles for engines and turbines. Material and energy balances for combustion processes. Thermochemistry.

335. Fluid Flow. (3-0) Cr. 3. F.S.SS. *Prereq: 331, E M 345, Math 266 or 267.* Incompressible and compressible fluid flow fundamentals. Dimensional analysis and similitude. Internal and external flow applications.

360. Engineering Measurements and Instrumentation. (2-3) Cr. 3. F.S. *Prereq: 311.* Fundamentals of design, selection, and operation of components of measuring systems. Measurement processes, analysis of data, and propagation of measurement uncertainty. Applications. Taught as an open laboratory.

411. Industrial Automatic Controls. (2-2) Cr. 3. S. *Prereq: 311.* Methods and principles of automatic control. Pneumatic, hydraulic, and electrical systems. Representative applications of automatic control systems. Mathematical analysis of control systems.

412. Legal and Environmental Considerations in Design. (3-0) Cr. 3. F. *Prereq: 312, senior classification in engineering.* Failure modes associated with product environment. Interaction between the legal profession, legislative bodies, standards and the design engineer, using a case study approach in design applications. Litigation involving designs, standards, and laws applicable to specific designs surveyed. The influence of laws and standards upon design.

414. Hydraulic Systems and Control. (3-0) Cr. 3. S. *Prereq: 311, 335.* Characteristics and design of pumps. Hydraulic motors, system components, system analysis, feedback control and stability, control circuits, analog simulation.

415. Mechanical Systems Design. (0-6) Cr. 3. F.S. *Prereq: 311, 312.* Solution of a total design problem involving a mechanical system, documenting decisions concerning environment impact, form and tolerance, material specification, thermal mechanical treatments, methodology of manufacture, presentation of the design.

***436. Heat Transfer.** (3-0) Cr. 3. F.S.SS. *Prereq: 331, 335 or E M 378, Math 267. Heat transfer* by conduction, convection and radiation. Similarity and analog concepts in heat, mass and momentum transfer. Methods for determination of heat transfer coefficients. Combined modes of heat transfer. Heat exchangers.

441. Refrigeration and Air Conditioning. (3-0) Cr. 3. F. *Prereq: Creidt or classification in 336 or 436.* Fundamentals of vapor compression, absorption, thermoelectric and air refrigeration systems. Cryogenic cycles used to liquefy and separate gases. Applications to air conditioning, food processing, low temperature storage, and superconducting systems.

***442. Heating and Air Conditioning Design.** (2-3) Cr. 3. S. *Prereq: 441.* Analysis of building energy requirements. Development of active and passive methods for heating and cooling structures. Design and layout of heating, ventilation and air conditioning systems.

***443. Thermal Power Plants.** (4-0) Cr. 4. F. *Prereq: E E 351 or 447.* Introduction to thermodynamics. Power plant cycles, fossil fuel electric generating station components, steam generators, steam and gas turbines, condensers, cooling towers and plant auxiliaries.

444. Elements and Performance of Power Plants. (3-0) Cr. 3. F. *Prereq: 332, credit or classification in 436.* Analysis of power supply systems and their components: turbines, steam generators, fans, pumps, heat exchangers, cooling water systems. Environment pollution and control.

445. Internal Combusion Engines. (2-2) Cr. 3. F. *Prereq: 332, credit or classification in 436.* Basic principles, thermodynamics, and performance of carbureted and fuel injection engines. Engine-drive train-vehicle considerations. Properties of engine fuels, combustion generated air pollutants. Laboratory determination of engine performance.

446. Power Plant Design. (2-3) Cr. 3. S. *Prereq: 444.* Design of a power plant to meet a specified power (energy) demand. Selection and/or synthesis of principal components and pollution control equipment.

447. Gas Turbines. (2-0) Cr. 2. S. *Prereq: 332, 335.* General principles, thermodynamics and performance of gas turbine engines. Engine components, engine matching and selection. Environmental considerations.

448. Fluid Dynamics of Turbomachinery. (2-3) Cr. 3. S. *Prereq: 335.* Applications of principles of fluid mechanics and thermodynamics in performance analysis of turbomachines and related fluid system components. Design problems.

451. Engineering Acoustics. (E M 451) See *Engineering Science and Mechanics.*

460. Experimental Engineering. (0-3) Cr. 1. F.S. *Prereq: 332, 360, 436.* Experimental investigation of selected problems taken primarily from thermodynamics, fluid mechanics, heat transfer and applied areas of mechanical engineering. Emphasis on application of classroom theory to experimental engineering and on interpretation and presentation of the results.

470. Computer-Aided Design. (3-0) Cr. 3. F. *Prereq: Senior classification in engineering and an elementary knowledge of FORTRAN.* An examination of the morphology of design processes, the structure of the FORTRAN language, figures of merit, searching and optimization techniques leading to an algorithmic approach to design.

475. Numerical Methods in Mechanical Engineering. (3-0) Cr. 3. S. *Prereq: Credit or classification in 436.* Numerical solution techniques common to many engineering problems, including those governed by ordinary and partial differential equations. Digital computer applications to problems drawn primarily from thermal and mechanical systems.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

502. Intermediate Machine Design. (3-0) Cr. 3. S. *Prereq: 415.* Mathematical, experimental and simulative solutions to problems of synthesis in the design of machines. Choice of work determined by aptitudes and interests of the class and instructor.

510. Dynamics of Fluid Control Systems. (3-0) Cr. 3. F. *Prereq: 335, 411.* Dynamical characteristics of fluid control systems and elements.

514. Computer and Reliability Considerations in Design. (4-0) Cr. 4. S. *Prereq: 312.* Design methodology, structure of FORTRAN language and their relationship to algorithmic approaches to design. Applications. Statistical representation of loading, material properties and geometric form. Probabilistic criteria for static and fatigue failure. A posteriori reliability assessment. A priori design to a reliability specification.

515. Advanced Design of Machine Elements. (3-0) Cr. 3. F. *Prereq: 312.* Experimental, empirical, and rational methods for analysis and synthesis in the solution of advanced design problems in machine elements. Creep and fatigue considerations.

516. Kinematic Analysis and Synthesis of Mechanisms. (3-0) Cr. 3. S. *Prereq: 310.* Analysis and synthesis of mechanisms using graphical, analytical, and computational methodologies.

518. Advanced Dynamics of Machinery. (3-0) Cr. 3. F. *Prereq: 311.* Dynamic forces in machine members. Principle of superposition. Dynamic response of cam-follower systems. Rotating and reciprocating machine unbalance. Forces transmitted and machinery isolation. Computer simulation of dynamic response.

520. Material and Manufacturing Considerations in Design. (3-0) Cr. 3. S. *Prereq: 312, 322.* Material selection consistent with functional requirements and process capabilities. Redesign of a product to facilitate manufacturing. Tolerances, surface finish, and surface integrity. Economic considerations. Exploring the engineer's responsibility in light of conflicting interests of designer, manufacturer, management, customer, and the public.

521. Properties of High Polymers. (M S E 521) (3-0) Cr. 3. S. *Prereq: M S E 270 or 271.* Molecular structure and packing, linear viscoelasticity, viscoelastic transitions, melt rheology, and mechanical properties. Effects of chemical structure and morphology on mechanical properties emphasized, and engineering aspects discussed.

526. Friction and Wear. (3-0) Cr. 3. F. *Prereq: M S E 270 or 271, E M 324.* Structure of solid surfaces, surface energetics and adhesion. Theories of friction. Forms of wear and relationship to microstructure and properties. Effect of lubrication on friction and wear. Tire and brake performance. Friction in deformation processing.

528. Plastic Forming Processes. (3-0) Cr. 3. F. *Prereq: 322 or M S E 302.* Concepts in continuum mechanics and physical metallurgy applied to the study of forming processes and their effect on the properties of the manufactured product.

***530. Intermediate Topics in Thermodynamics.** (2-0) Cr. 2. S. *Prereq: 332.* Thermodynamic analysis of unsteady flow processes. General equations for properties of pure substances. Real gas equations of state and processes for real gases. Quantitative evaluation of availability and irreversibility in thermodynamic processes.

531. Statistical Thermodynamics for Engineers. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 330 or 331.* First and Second Laws of Thermodynamics, properties of gases, liquids, and solids from a microscopic viewpoint. Introduction to non-equilibrium thermodynamics. Onsager relationships and determination of transport properties.

532. Thermodynamics of Compressible Flow I. (3-0) Cr. 3. F. *Prereq: 335.* Thermodynamics of internal compressible flow. One dimensional steady flow: isentropic flow, normal shock waves, constant area flow with friction and heat transfer. Generalized one dimensional flow.

533. Thermodynamics of Compressible Flow II. (Aer E 533) (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 532.* Theory of unsteady compressible flow and steady two dimensional supersonic internal flow. Compression and expansion waves and wave interactions. Applications.

534. Experimental Gas Dynamics. (Aer E 534) (1-3) Cr. 2. Alt. S., offered 1983. *Prereq: 332.* Shock waves, explosions, and compressible flows of high speed and high enthalpy. Equipment and instrumentation for flow visualization and measurement of thermodynamic properties, heat transfer, shock strength, and boundary layer phenomena. Use of shock tube as an experimental tool.

535. Hydrodynamic Lubrication. (3-0) Cr. 3. F. *Prereq: 312, 335.* Theory of fluid film lubrication and application to bearing design.

536. Advanced Heat Transfer. (3-0) Cr. 3. S. *Prereq: 336 or 436.* Advanced treatment of heat transmission by conduction, convection and radiation. Intended for those who require a general coverage of theory and methods but whose primary research interests are in other areas.

537. Experimental Fluid Mechanics. (E M 537) (1-3) Cr. 2. S. *Prereq: 571.* Experimental aspects of fluid mechanics including fundamentals of measurement of flow field velocities, pressures, and temperatures.

540. Solar Energy Thermal Systems. (3-0) Cr. 3. S. *Prereq: 336 or 436.* Application of heat transfer and thermodynamics to the design and analysis of solar energy collectors and systems.

541. Human Thermal Environments. (Arch 541) (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 440 or 441 or Arch 412.* Investigation of physical, climatological, and physiological factors that influence human response to thermal environments. Analytical methods for evaluating thermal performance of buildings and for quantitatively expressing human response to indoor thermal environments.

542. Advanced Combustion. (3-0) Cr. 3. S. *Prereq: 332.* Third Law and asolute entropy. Thermochemistry and energy balances. Gas phase equilibrium. Flame temperatures, speed and propagation. Reaction kinetics. Theories of the mechanisms of combustion. Air pollution control.

543. Energy Systems Engineering. (E E 543, Nuc E 543) (2-0) Cr. 2. F. *Prereq: One course in thermodynamics, E E 441, Econ 201 or 203 or I E 304.* Potentials and limitations of energy sources. Energy conversion, utilization, and conservation in industrial, residential, and transportation systems. Energy-related economic environmental, social, and political considerations.

545. Vehicular Propulsion Systems. (3-0) Cr. 3. S. *Prereq: 532 and 548 or Aer E 412.* Analysis and selection of propulsion systems for vehicles.

546, 547. Computational Fluid Mechanics and Heat Transfer I, II. (Aer E 546, 547) (3-0) Cr. 3 each. Yr. *Prereq: 546: credit or classification in 571 or Aer E 541; 547: 546.* 546: Introduction to finite difference methods used in modern engineering. Solution of example problems in fluid mechanics and heat transfer. 547: Application of computational methods to current problems in fluid mechanics and heat transfer.

548. Turbomachinery. (2-3) Cr. 3. F. *Prereq: 335.* Intermediate level study of turbomachines and related fluid system components. Aerodynamic and aeromechanical performance measurement and evaluation.

551. Noise Source Analysis. (E M 551) See *Engineering Science and Mechanics.*

560. Design of Engineering Experiments I. (2-3) Cr. 3. F. *Prereq: Graduate standing, 1 undergraduate engineering laboratory course and elementary knowledge of statistics.* Fundamentals of design, selection and operation of instrumentation components of measuring systems. Techniques for analysis, interpretation, and presentation of experimental data. Error analysis and propagation of error. Statistical inference acceptance tests and comparison tests, precision and confidence limits on data resulting in points, lines, or curves.

561. Design of Engineering Experiments II. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 360 or 560.* Design of experiments to determine what data to take, how much data to take, as well as to meet prescribed confidence limits on results. Selection of complete measurement systems to satisfy the response, sensitivity, resolution, isolation, and fidelity required by specifications of the experiment.

564. Fracture and Fatigue. (E M 564, M S E 564). (3-0) Cr. 3. F. *Prereq: E M 324 and any one of E M 337, E Sci 352, M S E 231, 270 or 271.* Materials and mechanics approach to fracture and fatigue. Fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics. Fracture and fatigue tests, thermal fracture, mechanics and materials designed to avoid fracture and fatigue.

571, 572. Advanced Fluid Mechanics. (E M 571, 572). See *Engineering Science and Mechanics.*

590. Special Topics. Cr. 1 to 8. Investigation of problems of special interest to graduate students in mechanical engineering. Election of course and problem must be approved in advance. A. through G., J. through L. (See listing under 490.)

Courses for Graduate Students, major or minor

600. Seminar. (1-0) Cr. R. F.

602. Advanced Machine Design. (3-0) Cr. 3. *Prereq: At least two of 510, 514, 515, 516, 518, E M 514, 517, 544.* Concepts, principles, theories, and procedures useful for synthesis decisions in advanced machine design including computational aids with an emphasis on high speed applications. Choice of work determined by aptitudes and interests of the class and instructor.

***630. Advanced Engineering Thermodynamics I.** (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 331.* Fundamental concepts of thermodynamics, including laws, termperature, entropy and general equations for property changes of non-reactive systems. Construction of tables of properties. Equilibrium criteria.

631. Advanced Engineering Thermodynamics II. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 331.* Nonequilibrium concepts in thermodynamics leading to rate processes in liquids and high temperature gases. Laws governing gas-liquid phase equilibria and evaporation rate; gas phase transport phenomena and chemical reaction rate. Combustion applications are droplet and surface burning, flame propagation in premixed and diffusion gases, and nozzle flow.

632. Particulate Flow. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 436.* Concepts in single and multiparticle phenomena; particle interactions with fluids, other particles and walls; equations of multiphase ducted flow. Dense packing particle behavior including heat and mass transfer in fixed and fluidized beds.

636. Conduction Heat Transfer. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 436.* Techniques for analysis of problems involving steady-state and transient heat conduction in solids.

637. Convection Heat Transfer. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 436.* Heat transfer to internal or external forced convection flows under laminar or turbulent conditions. Free convection. Heat exchanger design considerations, including augmentation.

638. Radiation Heat Transfer. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 436.* Techniques for analysis of radiation in enclosures. Radiative properties of surfaces. Radiative transfer in participating media. Combined modes of transfer. Approximate methods of analysis.

639. Two-Phase Flow and Heat Transfer. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 436.* Hydrodynamics of adiabatic two-phase flow. Pool boiling. Forced convection and boiling condensation. Dynamic behavior of two-phase systems. Augmentation of boiling and condensing heat transfer. Applications in the power and process industries.

640. Advanced Thermal Environmental Engineering. (2-3) Cr. 3. Alt. F., offered 1981. *Prereq: 441, 360 or 560.* Application of non-steady thermodynamics analysis to the thermal performance of buildings. Investigation of part-load performance of systems.

650. Fluid Mechanics Seminar. (Aer E 650, E M 650) (1-0) Cr. 1 each time taken. F. *Prereq: Permission of instructor.* Special topics of current research interest to students and staff of departments concerned.

651. Advanced Topics in Fluid Mechanics. (E M 651) See *Engineering Science and Mechanics.*

690. Advanced Topics. Cr. Var.

699. Research.

***Credit for both 530 and 630 may not be applied toward graduation.**

Metallurgical Engineering

For description of courses, see *Materials Science and Engineering.*

Metallurgy

For description of courses, see *Materials Science and Engineering.*

Meteorology

For description of courses, see *Earth Sciences.*

Microbiology

(Bacteriology)

Paul A. Hartman, Chair of Department

The Graduate Faculty

Members: Atherly, Durand, Glatz, Hartman, Holt, Kraft, Lockhart, Pattee, Quinn, Walker, Williams

Associate Member: Loynachan

The department offers work the degrees Master of Science and Doctor of Philosophy with major in microbiology, and minor work to students majoring in other departments. Within the major the student may specialize in immunology; in virology; in food, applied, medical, or systematic bacteriology; or in microbial ecology, genetics, physiology, or morphology. Major graduate study in veterinary microbiology, soil microbiology, and dairy microbiology is offered in the departments of Veterinary Microbiology, Agronomy, and Food Technology, respectively.

Specific prerequisite to major work in microbiology is the completion of thorough course work in general microbiology, biology, organic chemistry, biochemistry, mathematical sciences, and physics. Minor study usually is selected from chemistry, biochemistry and biophysics, botany, zoology, genetics, mathematics, computer science, and statistics.

The department also participates in the interdepartmental programs in Immunobiology; Molecular, Cellular and Developmental Biology; and Water Resources (see Index).

Each graduate student must have received a grade of B or better in English composition or pass the Graduate English Examination within two semesters in residence.

Candidates for the Ph.D. degree must demonstrate their ability to translate scientific articles from one modern foreign language. Language examinations are administered by the department. Graduate students are encouraged to teach at least one laboratory section each year in residence.

Courses for Graduate Students, minor only

310. Pathogenic Microbiology. (3-4) Cr. 4. F.SS. *Prereq: 300; a course in organic chemistry.* Study of pathogenic bacteria and other microorganisms. Clinical laboratory techniques for the identification and characterization of pathogens.

320. Advanced General Bacteriology. (3-6) Cr. 5. S. *Prereq: 300; a course in organic chemistry.* A survey of the procaryotes with emphasis on bacterial physiology, cytology and ecology. The isolation, cultivation, and study of bacteria.

400. Molecular Biology of Bacteria and Viruses. (3-0 or 3-4) Cr. 3 or 4. F. *Prereq: 300, Gen 330.* Survey of bacterial, plant and animal virology. Emphasis on bacterial genetics and virus host-cell interactions. Laboratory emphasizes mutagenesis and genetic characterization of bacteria and principles and techniques involved in the quantitation, isolation and, characterization of bacteriophage.

401. Food Processing. (F Tch 401) See *Food Technology.*

402. Food Processing Laboratory. (F Tch 402) See *Food Technology.*

420. Food Microbiology. (F Tch 420) (3-0) Cr. 3. F. *Prereq: 300.* The normal microbial flora of foods; microbiological indicators of contamination; food-borne infections and intoxications; food safety.

421. Food Microbiology Laboratory. (F Tch 421) See *Food Technology.*

425. Food and Water Sanitation. (F Tch 425) See *Food Technology.*

485. Soil Biology. (Agron 485) See *Agronomy.*

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

506. Host-parasite systems. (Zool 506) See *Zoology.*

508. Vertebrate Virology. (2-0 or 2-4) Cr. 2 or 3. S. *Prereq: 400; permission of instructor required for laboratory.* Molecular biology and pathology of vertebrate viruses. Laboratory emphasizes the isolation, quantitation, and characterization of vertebrate viruses.

509. Plant Virology. (PP SW 509) See *Plant Pathology, Seed and Weed Sciences.*

520. Medical Immunology I. (VMPM 520; Imbio 520) See *Veterinary Microbiology and Preventative Medicine.*

524. Veterinary Medical Mycology. (VMPM 524) See *Veterinary Microbiology and Preventative Medicine.*

525. Applied Microbiology. (3-0) Cr. 3. S. *Prereq: 300, permission of instructor.* Utilization of microorganisms in agriculture and industry.

526. Advanced Veterinary Virology. (VMPM 526) See *Veterinary Microbiology and Preventative Medicine.*

550. Seminar. Cr. 1 each time taken. F.S. Required of all students taking major graduate work in microbiology. Offered on a satisfactory-fail basis only.

560. Immunoparasitology. (Vet Pth 560) See *Veterinary Pathology.*

575. Immunology. (Imbio 575) (3-0 or 3-6) Cr. 3 or 5. F.S. *Prereq: 300; laboratory by permission of instructor.* Theories of immunity and immunization; antigen-antibody reactions. Laboratory deals with preparation and use of vaccines and antisera; immunological techniques.

585. Soil Microbiology and Biochemistry. (Agron 585) See *Agronomy.*

Courses for Graduate Students, major or minor

600. Comparative Anatomy and Physiology of Bacteria. (3-0 or 3-3) Cr. 3 or 4. F. *Prereq: Course in microbiology and biochemistry.* Metabolism, growth and cultivation of bacteria; structure of bacteria as related to function. Laboratory emphasizes the cultivation and manipulation of bacteria as research tools for the study of comparative physiology and molecular biology.

610. Genetics of Bacteria and Bacteriophage. (2-0 or 2-6) Cr. 2 or 4. S. *Prereq: Course in microbiology and genetics.* Advanced course in genetics and molecular biology of bacteria and bacterial viruses. Laboratory is a continuation of Bact 600 laboratory.

612. Current Topics in Parasite Ecology, Evolution, and Systematics. (Zool 612).

615. Molecular Immunology. (B B 615) See *Biochemistry and Biophysics.*

620. Molecular Genetics. (Gen 620) See *Genetics.*

626. Advanced Food Microbiology. (F Tch 626) See *Food Technology.*

685. Advanced Soil Biochemistry. (Agron 685) See *Agronomy.*

690. Advanced Topics. Cr. 1 to 5 each time elected. *Prereq: Permission of instructor.* Selected topics of current interest.

698. Seminar in Molecular, Cellular, and Development Biology. (MCDB 698) See *Molecular, Cellular, and Development Biology.*

699. Research.

*Course offered at the Gulf Coast Research Laboratory.

452G. Marine Microbiology. Cr. 5. SS. Offered for undergraduate credit through a cooperative arrangement with Iowa State University. *Prereq: 8 semester credits in microbiology.* A general course designed to introduce the microbiology and advanced biology student to the role of microorganisms in the over-all ecology of the oceans and estuaries.

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*Written permission of the coordinator of the Gulf Coast Research Laboratory, 201 Bessey Hall, Iowa State University, Ames, Iowa 50011, is prerequisite to all courses offered at the Laboratory.

Courses taught in the Department of Botany:

Bot 406. Principles of Mycology.
Bot 500. Field Biology of Freshwater Algae.
Bot 641, 642. General Mycology.
Bot 679. Light and Scanning Electron Microscopy.
Bot 681. Transmission Electron Microscopy.

Molecular, Cellular, and Developmental Biology

(Interdepartmental Major)

S. Bishop, Chair, Supervisory Committee

Supervisory Comittee: G. C. Brown, J. Horowitz, M. H. Stromer

Work is offered for the degrees Master of Science and Doctor of Philosophy with major in molecular, cellular, and developmental biology in several cooperating departments: Animal Science, Biochemistry and Biophysics, Botany, Food Technology, Genetics, Microbiology, and Zoology.

Facilities and qualified faculty are available in these departments for conducting fundamental research in the three focal areas of the program: structure and function of muscle; mechanisms of information storage and transfer; cell interactions and membranes. Ongoing research involves studies with viral, prokaryotic, and eukaryotic systems.

Students majoring in molecular, cellular, and developmental biology will become affiliated with a department and choose a major professor from the participating faculty in that department. All Ph.D. students take a core curriculum consisting of the following courses: one year of biochemistry (B B 404, 405 or B B 501, 502), molecular genetics (Gen 620 or Micro 610), cell biology (B B 526 or Zool 528), developmental biology (B B 675, Gen 619, Zool 534 or Zool 631) and seminar in MCDB (MCDB 698). M.S. students take the above core but may delete either the molecular genetics, cell biology, or developmental biology complement. Additional course work is selected to meet departmental requirements and to satisfy individual student research interests; courses may be chosen from those listed below. The foreign language requirement is determined by the student's major department.

All graduate students are required to teach as part of their training for an advanced degree.

Courses for Graduate Students, major or minor

508. Vertebrate Virology. (Micro 508) See *Microbiology.*

509. Plant Virology. (PP SW 509) See *Plant Pathology, Seed and Weed Sciences.*

512. Plant Growth Regulation. (Bot 512) See *Botany.*

526. Cell Biology of Selected Eukaryotic Cell Systems. (B B 526) See *Biochemistry and Biophysics.*

528. Cellular Growth and Regulation. (Zool 528) See *Zoology.*

529. Fine Structure of Plant Cells. (Bot 529) See *Botany.*

534. Molecular Development and Differentiation. (Zool 534) See *Zoology.*

535. Laboratory in Cytogenetics. (Gen 535) See *Genetics.*

547. Biological Applications of Microscopy. (F Tch 547) See *Food Technology.*

560. Evolutionary Genetics. (Gen 560) See *Genetics.*

574. Microscopy. (B B 574) See *Biochemistry and Biophysics.*

575. Laboratory in Microscopy. (B B 575) See *Biochemistry and Biophysics.*

590. Special Topics. Cr. Arr.

600. Comparative Anatomy and Physiology of Bacteria. (Micro 600) See *Microbiology.*

610. Genetics of Bacteria and Bacteriophage. (Micro 610) See *Microbiology.*

615. Molecular Immunology. (B B 615) See *Biochemistry and Biophysics.*

619. Developmental Genetics. (Gen 619) See *Genetics.*

620. Molecular Genetics (Gen 620) See *Genetics.*

621. Somatic Cell Genetics. (Gen 621) See *Genetics.*

630. Current Topics in the Cellular and Molecular Biology of Animal Systems. (Zool 630) See *Zoology.*

631. Advanced Developmental Biology. (Zool 6312) See *Zoology.*

632. Cellular Regulation. (Zool 632) See *Zoology.*

645. Biochemistry of Metabolic Regulation. (B B 645) See *Biochemistry and Biophysics.*

670. Molecular Biology of Muscle. (An S/B B 670) See *Animal Science.*

675. Nucleic acids and Gene Regulation. (B B 675) See *Biochemistry and Biophysics.*

679. Light and Scanning Electron Microscopy. (Bot 679) See *Botany.*

680. X-ray Microanalysis Using Scanning Electron Microscopy. (Bot 680) See *Botany.*

681. Transmission Electron Microscopy. (Bot 681) See *Botany*

698. Seminar in Molecular, Cellular, and Developmental Biology. (B B 698, Bot 698, Gen 698, Micro 698, Zool 698) (1-0) Cr. 1. F.S. Student and faculty presentations.

699. Research

Music

Arthur G. Swift, Head of Department

The Graduate Faculty

Members: Bleyle, White

Associate Members: Burkhalter, Messenger, Swift, Woods

Courses for Graduate Students, minor only

430. Seminar in Analysis for Performance. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 331.* Analysis and performance of selected works appropriate to student's performance medium. Examination of structural, rhythmic, harmonic, and textural aspects of the music selected. Literature will vary according to the needs of the class.

440. Seminar in Music Theory. (3-0) Cr. 3. S. *Prereq: 331.* Various topics in music theory including counterpoint, arranging, pedagogy, and psychology of music. Content will vary. Contact the Music Department for the current year offering.

471. Seminar in Music History. (2-0) Cr. 2. F. Various topics in music history including keyboard music, choral music, and chamber music. Content will vary. Contact the Music Department for the current year offering.

472. History of American Music. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 9 credits from music, American literature, American history, art history.* Serious and popular currents that have influenced development in American music and its relation to transcendentalism, mass culture, and other intellectual, social, and cultural trends in the history of America.

473. Music of the Baroque Era. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 383, 384.* Detailed survey of instrumental, vocal, choral, and keyboard music from 1600 to 1780.

474. Music of the Classical Era. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 383, 384.* Detailed survey of instrumental, vocal, choral and keyboard music from 1780 to 1825.

475. Music of the Romantic Era. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 383, 384.* Detailed survey of instrumental, vocal, choral and keyboard music from 1825 to 1910.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

590. Special Topics. Cr. var. F.S.SS. *Prereq: Permission of instructor, approval of department head.*
A. Education
B. Theory
C. Composition
D. History
E. Literature
F. Applied Music

Nuclear Engineering

George Burnet, Chair of Department

The Graduate Faculty

Members: Burnet, Danofsky, Ma, Roberts, Rohach, Sabri, Wechsler

Associate Professors: Barcus, Hendrickson, Valfells

The department offers work for the degrees Master of Science, Master of Engineering, and Doctor of Philosophy with a major in nuclear engineering. Minor work in nuclear engineering is offered to students taking major work in other departments.

Students may prepare for graduate work in nuclear engineering by pursuing undergraduate programs in engineering or in the physical sciences. It is recommended that students contemplating graduate studies in nuclear engineering include courses in modern physics, heat transfer, thermodynamics, chemistry, and mathematics (beyond differential equations) as part of their undergraduate preparation.

Admission to the EAC/ABET-accredited Master of Engineering program is restricted to thoise students having a bacherlor's degree from an EAC/ABET-accredited engineering curriculum or the equivalent.

For the degree Doctor of Philosophy, a foreign language may be required by the student's program of study committee.

Because materials are an important aspect of nuclear engineering, there is an interdisciplinary arrangement with the Department of Materials Science and Engineering. Nuclear engineering students interested in materials aspects of nuclear energy technology are encouraged to consider the following courses: M S E 375, 401, 402, 520, 522, 523, 551, 552, and 650.

The department also participates in the interdepartmental minor programs of Energy Systems Engineering, Water Resources, and Technology and Social Change. (See Index.)

Courses for Graduate Students, minor only

331. Fission Reactor Analysis. (4-0) Cr. 4. F. *Prereq: 221, credit or classification in Math 267.* Neutron moderation and diffusion. Theory of homogeneous and heterogeneous reactors. Reactor kinetics and control. Fission product buildup and poisoning. Fuel burnup. Numerical techniques.

361. Nuclear Engineering Laboratory. (2-3) Cr. 3. S. *Prereq: 221, credit or classification in Math 267.* Principles of nuclear radiation detection and measurement. Counting statistics. Detection system performance parameters. Data reduction and analysis. Problems involving reactor engineering measurements.

401. Nuclear Power Engineering. (3-0) Cr. 3. F. *Prereq: Math 266, Phys 222.* Atomic structure, radioactivity, nuclear reactions, neutron interactions. Basic reactor theory, kinetics and control. Energy generation and removal. Nuclear reactor systems. Regulations. Not acceptable for credit for a nuclear engineering degree.

411. Radiation Protection and Dosimetry. (2-2) Cr. 3. S. *Prereq: 221.* Radiation units. Somatic and genetic effects of radiation. Natural and man-made radiation sources. Standards of radiation protection.

441. Safety and Control of Nuclear Systems. (3-0) Cr. 3. S. *Prereq: 331.* Nuclear reactor dynamics and control. Safety analysis. Assessment of magnitudes and consequences of nuclear incidents. Reactor siting, containment, and engineered safeguards. Regulations.

444. Time Behavior of Nuclear Reactor Systems. (3-0) Cr. 3. S. *Prereq: 331.* Development of time-dependent nuclear reactor models, space-independent kinetic equations, reactivity feedback, and linear system stability. Nuclear power plant dynamics.

451. Nuclear Fuel Cycles, Processes, and Management. (3-0) Cr. 3. F. *Prereq: 331, I E 304, M S E 375.* Ore processing. Uranium enrichment. Fuel fabrication. Spent fuel reprocessing. Radioactive waste handling and disposal. In-core fuel management. Nuclear safeguards. Economic analysis.

471. Fusion Reactor Systems. (3-0) Cr. 3. S. *Prereq: 331.* The technological requirements of power production by nuclear fusion. Plasma fueling and recovery, fuel cycles and control. Energy conversion, neutronics, and blanket design. Magnetic and laser fusion systems. Fission-fusion hybrids. Safety aspects.

481. Nuclear Power System Analysis and Design I. (2-3) Cr. 3. F. *Prereq: 331, credit or classification in M E 436.* Nuclear reactor core and component analysis and design. Nuclear reactor core thermal and hydraulic analysis and design. Critical heat flux and hot spot factors. Applications of numerical techniques. Iterative techniques in design.

482. Nuclear Power System Analysis and Design II. (1-6) Cr. 3. S. *Prereq: 451, 481, credit or classification in 441.* Integration into systems design. Shielding design. Thermodynamic aspects of nuclear power plants. Kinetics and control. Plant stability and transient behavior. Fuel burnup and fuel management. Fuel costs. Over-all safety assessment.

484. Nuclear Radiation Engineering. (3-0) Cr. 3. S. *Prereq: 221.* Nuclear engineering applications other than those oriented towards large scale power production. Isotopic power sources. Radiation gauging. Biomedical, agricultural, and chemical industry uses of radiation. Neutron radiography and activation analysis.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

521. Nuclear Physics for Engineers. (3-0) Cr. 3. F. *Prereq: Math 266, Phys 222.* Introduction to relativity, quantum theory. Fundamental particles and nuclear models. Nuclear reactions and decay. Isotopes and radiation. Fission and fusion reactions.

531. Nuclear Reactor Theory I. (4-0) Cr. 4. F. *Prereq: 331, 521.* Neutron moderation and diffusion. Theory of homogeneous and heterogeneous reactors. Introduction to perturbation and transport theories.

532. Nuclear Reactor Theory II. (3-2) Cr. 4. S. *Prereq: 531.* Space-independent kinetic equations, time-dependent reactivity, reactivity feedback and linear system stability, nuclear power plant models. Fuel burnup, fission product buildup and poisoning. Reactor control.

535. Nuclear Radiation Shielding. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 531, 581.* Analysis of shielding systems for protection against gamma radiation and neutrons. Kernel techniques. Heat generation in shields. Shield optimization. Charged particle shielding.

541. Nuclear Safety Evaluation Methods. (3-0) Cr. 3. S. *Prereq: 441.* Methods for quantifying accident probabilities, fault tree analysis, reliability assessment, and simulation techniques.

543. Energy Systems Enginering. (E E 543, M E 543) See *Mechanical Engineering.*

551. Radiation Effects on Materials I: Fundamental Radiation Damage. (M S E 551) (3-0) Cr. 3. F. *Prereq: M S E 270 or 271 or 375.* Characteristics of radiation environments. Scattering and absorption cross sections. Determination of neutron flux and spectrum. Defects in materials. Experimental observations of radiation damage. Effects of annealing and impurities.

552. Radiation Effects on Materials II: Application to Nuclear Systems. (M S E 552) (3-0) Cr. 3. S. *Prereq: 551.* Defect clusters, voids, and bubbles. Radiation hardening and embrittlement. Radiation effects on pressure vessel steels, fuel cladding, and core components. Radiation-induced swelling. Fuel restructuring and densification. Radiation effects on materials for fusion reactors. Radiation effects on non-metals, including semiconductors and polymers.

555. Processing of Nuclear Fuels and Wastes. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 451.* Nuclear fuel resource assessment. Ore processing. Isotope separation methods. Chemical reprocessing of nuclear fuels. Radioactive wastes processing and management. Environmental safeguards. Nonproliferation impact.

561. Nuclear Radiation Laboratory. (1-3) Cr. 2. F. *Prereq: Credit or classification in 521.* Statistical methods in radiation detection. Nuclear electronics. Data reduction and analysis. Applications to engineering problems.

571. Nuclear Fusion Theory. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 471, 521.* Principles of controlled thermonuclear fusion reactions, thermonuclear plasma production, confinement, heating, and diagnostics. Impurity effects and fusion energy release.

581. Nuclear Reactor Thermal Systems. (3-0) Cr. 3. S. *Prereq: 331, 441.* Applications of nuclear power utilization. Power cycles, heat transfer, thermodynamics and fluid dynamic aspects of reactor systems.

582. Nuclear Reactor Engineering Systems. (3-0) Cr. 3. F. *Prereq: 481 or 581.* Thermal and mechanical limitations of the nuclear steam supply system. Burnout correlations. Thermal, irradiation, and mechanical effects upon stress analysis of reactor components.

585. Nuclear Power Plant System Design. (1-4) Cr. 3. S. *Prereq: Credit or classification in 532, 582.* Overall design of nuclear power plants. A group project with individual component or system design and integration into the total project. Component and material selection. Control, shielding, siting, licensing, engineered safeguards, and economic considerations.

590. Special Topics. Cr. var. Toipics of special interest in nuclear engineering.

Courses for Graduate Students, major or minor

621. Advanced Nuclear Theory. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 521.* Advanced theory of nuclear cross sections. Nuclear models. Theoretical and experimental considerations.

631, 632. Advanced Nuclear Reactor Theory. (3-0) Cr. 3 each. Alt. Yr., offered 1982-83. *Prereq: 631: 532; 632: 631.* Advanced topics in nuclear reactor theory. Perturbation theory. Synthesis methods. Variational techniques. Transport theory. Monte Carlo methods.

642. Advanced Nuclear Reactor Dynamics. (4-0) Cr. 4. Alt. S., offered 1982. *Prereq: 532.* Space-dependent reactor dynamics. Non-linear system stability. Application of random noise techniques to reactor systems. Rossi-alpha and variance to mean experiments.

650. Nuclear Reactor Fuels. (M S E 650) (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 552 or M S E 375.* Physical, chemical, nuclear, thermal, and mechanical properties of metallic, ceramic, and liquid fuels for nuclear reactors. Fuel cycles and fuel element design in thermal and fast reactors. Fuel fabrication. Behavior of fission products. Fuel restructuring and densification. Implications for safety and economics of nuclear reactors.

654. Nuclear Fuel Management. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 451, 532.* Methodologies in nuclear fuel management. Advanced numerical techniques. Optimization techniques in nuclear fuel management.

661. Advanced Nuclear Engineering Laboratory. (2-3) Cr. 3. S. *Prereq: Credit or classification in 532, 561, 582.* Performance evaluation of nuclear systems using standard and experimental measurement methods.

671. Advanced Nuclear Fusion Theory. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 571.* Plasma, particle transport theory and equations. Important plasma devices in experiments, fundamental scaling laws, radiation energy losses, plasma stability and fusion reactor design concepts.

681. Advanced Nuclear Engineering Analysis. (2-2) Cr. 3. Alt. S., offered 1982. *Prereq: 532, 582.* Analysis of new concepts in nuclear engineering. Application of advanced computational techniques.

690. Advanced Topics. Cr. var.

695. Advanced Seminar. (1-0) Cr. R. F.S. Presentations and discussions of advances and problems in contemporary nuclear engineering.

699. Research.

Philosophy

John W. Elrod, Chairman of Department

The Graduate Faculty

Members: Elrod, Hollinger, Klemke, Kupfer, Robinson, Solomon, Van Iten

Associate Members: Hollenbach, Kline

The department offers courses for graduate minor work in studies in philosophy and participates in the interdepartmental programs in General Graduate Studies and Technology and Social Change. (See Index.)

Courses for Graduate Students, minor only

***310. Ancient and Medieval Philosophy.** (3-0) Cr. 3 or (3-1) Cr. 4. F. *Prereq: 201.* Plato's and Aristotle's metaphysics and epistemology, related to their moral and social theory. Some representative medieval philosophers such as Augustine and Aquinas, and such problems as free will and the existence of God.

***311. Modern Philosophy.** (3-0) Cr. 3 or (3-1) Cr. 4. S. *Prereq: 201.* Philosophy from the late Rennaissance to the late 18th Century. Our beliefs about our world, ourselves, our deities, and our morals. The nature of doubt and certainty, sources of knowledge and illusion.

***312. 19th and 20th Century Continental Philosophy.** (3-0) Cr. 3 or (3-1) Cr. 4. F. *Prereq: 201.* Hegel's philosophy and various responses to this philosophical position. Developments in phenomenology (e.g., Husserl, Heidegger, and Merleau-Ponty), existentialism (e.g., Kierkegaard, Nietzsche, and Sartre), and social and political philosophy (e.g., Marx and Habermas).

***313. Twentieth Century Anglo-American Philosophy.** (3-0) Cr. 3 or (3-1) Cr. 4. S. *Prereq: 201.* Main problems and themes of major movements in contemporary philosophy such as pragmatism, realism, common sense philosophy, logical positivism, and ordinary language philosophy. Readings include key works by representatives of these positions.

***320. Existentialism.** (3-0) Cr. 3 or (3-1) Cr. 4. F. *Prereq: 201.* Philosophical foundations of existentialism: Kierkegaard, Nietzsche, Sartre, and Heidegger. Its religious, literary, and psychoanalytic expressions: Dostoevsky, Tolstoy, Tillich, Buber, Marcel, Camus, Pursey, May, and Laing.

***332. Philosophy of Law.** (3-0) Cr. 3 or (3-1) Cr. 4. Alt. S., offered 1982. *Prereq: 201 or 230.* Extent of our obligation to obey the law; what constitutes just punishment; how much of the immoral should be made illegal? Relation of these questions to major theories of law and the state. Discussion of such concepts as coercion, equality, and responsibility.

***335. Social and Political Philosophy.** (3-0) Cr. 3 or (3-1) Cr. 4. F. *Prereq: 201.* Foundations of social and political life. Metaphysical and epistemological grounds in classical and recent thinkers. The basis of political organization, the nature of social and political institutions, rights and authority, justice and the character of distinctly political action. Original texts.

***340. Aesthetics.** (3-0) Cr. 3 or (3-1) Cr. 4. F. *Prereq: 201 or 230.* Is liking all there is to appreciating works of art or natural beauty? We will examine our appreciative experiences, *talk* about such experiences (e.g., art criticism), and what makes them *valuable*. Do the different arts have common values? How are their differences important?

***350. Philosophy of Religion.** (Relig 350) (3-0) Cr. 3. or (3-1) Cr. 4. S. Prereq: 201. The value and truth of religious life and belief. Mystical experience; religious faith and language; arguments for God's existence; the problem of evil; miracles; and religion and morality. Historical and contemporary readings from both the western and eastern traditions.

***380. Philosophy of Science.** (3-0) Cr. 3 or (3-1) Cr. 4. F. *Prereq: 201.* Introduction to the philosophy of science. A variety of basic problems common to the natural and social sciences: the nature of explanation, the structure of theories, the unity of science, and the distinction between science and non-science.

***381. Philosophy of the Social and Behavioral Sciences.** (3-0) Cr. 3 or (3-1) Cr. 4. S. *Prereq: 201 or 6 credits in the social sciences.* An examination of conflicting approaches to the study of human behavior, as represented by the social and behavioral sciences. Conflicts between different approaches against the backdrop of conflicting theories of scientific method. Similarities and differences between the social and natural sciences, as well as among the various social and behavioral sciences. Assumptions about the nature of human beings, values and societies; the value-neutrality of the social sciences and the ideological dimensions of the policy sciences. Selections from social scientists and philosophers.

430. Seminar: Value Theory. (3-0) Cr. 3 each time taken, maximum of 6 credits. S. *Prereq: 230.* Theoretical and normative issues in ethics, aesthetics, religious thought, or political philosophy. Topics vary each time offered.

460. Seminar: Epistemology and Metaphysics. (3-0) Cr. 3 each time taken, maximum of 6 credits. Alt. F., offered 1981. *Prereq: 201 and at least one course in the history of philosophy.* Issues in epistemology and metaphysics. Topics vary each time offered.

470. Seminar: Philosophical Systems. (3-0) Cr. 3 each time taken, maximum 6 credits. Alt. F., offered 1982. *Prereq: 201 and at least one course in the history of philosophy.* Focus upon philosophical systems: analysis of several philosophers forming a tradition or school, or one philosopher who offers a comprehensive system. Topics vary each time offered.

590. Special Topics in Philosophy. Cr. 2 to 4 each time taken. *Prereq: Permission of instructor; 9 credits in philosophy.*
A. History of Philosophy
B. Epistemology and Metaphysics
C. Value Theory
D. Logic and Philosophy of Science

***Optional fourth credit entails guided research or other complementary study.**

Religious Studies

Richard J. Van Iten, Chair, Advisory Committee

Advisory Committee: J. W. Elrod*, A. M. Fink, P. W. Hollenbach*, G. T. McJimsey, T. J. Solomon*, H. J. Weiss, M. B. Whiteford, D. B. Wilson

The program offers courses for graduate minor work in religious studies as supporting work for other fields.

***321. The Old Testament.** (3-0) Cr. 3, or (3-1) Cr. 4. F. *Prereq: 1 200-level course in religious studies.* Literature and religion of ancient Judaism understood within the context of ancient Near Eastern cultures. Particular attention given to the development of basic religious and ethical perspectives and their modern relevance.

***322. The New Testament.** (3-0) Cr. 3, or (3-1) Cr. 4. S.SS. *Prereq: 1 200-level course in religious studies.* Literature and religion of early Christianity within the context of contemporary Judaism and Hellenistic culture. Particular attention given to the development of basic religious and ethical perspectives and their modern relevance.

350. Philosophy of Religion (Phil 350). See *Philosophy*.

***353. Ways of Enlightenment: Hinduism and Buddhism.** (3-0) Cr. 3, or (3-1) Cr. 4. F. *Prereq: 1 200-level course in religious studies.* The various Hindu and Buddhist paths to realize enlightenment and freedom. Special attention to meditation and yoga and their relationship to altered states of consciousness and Western methods of psychophysical integration.

***365. Western Religious Thought.** (3-0) Cr. 3, or (3-1) Cr. 4. S. *Prereq: 1 200-level course in religious studies.* An examination of the religious and intellectual upheaval of the Reformation against its Medieval background and its subsequent development. Focus on a critical and sympathetic understanding of the major theological, philosophical, and historical forces which form contemporary Judaism, Catholicism, and Protestantism.

465. Seminar: Contemporary Western Religious Thought. (3-0) Cr. 3. S. *Prereq: 6 credits in religious studies.* Selected issues in contemporary religious thought including Protestant, Roman Catholic, Jewish, and secular thinkers.

475. Seminar: Issues in the Study of Religion. (3-0) Cr. 3 each time taken, maximum of 6 credits. Alt. F., offered 1981. *Prereq: Nine credits in religious studies.*

590. Special Topics in Religious Studies. Cr. 2 to 4 each time taken. *Prereq: Permission of instructor, 9 credits in religious studies.*
A. Western Religions
B. Eastern Religions
C. Religious Thought
D. Religion and Culture

***Optional fourth credit entails guided research or other complementary study.**

Physical Education and Leisure Studies

Barbara E. Forker, Head of Department

The Graduate Faculty

Member: Forker

Associate Members: Dean Anderson, Beran, Conover, Frye, Hutchison, Mathes, Pease, Puhl, Rupnow, Wood

The department offers work for the degree Master of Science with major in physical education and minor work to students taking major work in other departments.

The normal prerequisite to major graduate work is the satisfactory completion of a curriculum

essentially equivalent to that required of undergraduate students in physical education at this University. However, it is possible for students to qualify for graduate study even though undergraduate preparation has been in a related area.

A student in the graduate program may select either a thesis or non-thesis option. Specific information about the requirements for either degree option is available from the departmental office.

Courses for Graduate Students, minor only

Leisure Studies (L S)

355. Dimensions of Recreation in the Campus Community. (3-0) Cr. 3. F.S. *Prereq: 350.* Basic concepts in organization, administration, and program planning for recreation in the campus community.

453. Administration of Leisure Services. (3-2) Cr. 4. F.S. *Prereq: 350, 383.* Principles and practices of administering leisure programs and services.

494. Therapeutic Recreation Processes and Services. (1-3) Cr. 2. S. *Prereq: 394.* Applications of recreation concepts and leadership principles in serving ill, disabled, and other special populations. Nature and scope of services, settings, and agencies. Fee for field trips.

Courses Primarily for Graduate Students, open to qualified undergraduates

580. Theory and Philosophy of Leisure. (3-0) Cr. 3. *Prereq: 2 courses in leisure studies or related areas.* Theoretical and philosophical development of the leisure concept with application to the professional field of service. Historical development of theory and philosophy.

582. Strategies for Communication in Outdoor Recreation. (0-5) Cr. 2. *Prereq: 451.* Advanced skills, methods, and educational practices in program planning and in communicating values of the outdoor environment.

Physical Education (P E)

355. Kinesiology. (3-3) Cr. 4. F.S. *Prereq: Zool 156, Phys 101 or 106 or 111.* The study of anatomical and mechanical phenomena which underlie human motion. Includes the application of kinesiological concepts to a wide variety of physical education activities.

370. Principles of Motor Performance. (2-2) Cr. 3. F.S. *Prereq: Psych 101.* Factors influencing human motor performance. Review of principles applicable to design of motor learning experiences in physical education.

****390. Physical Education for the Developmentally Disabled.** (1-2) Cr. 2. F. *Prereq: Psych 230.* Etiology, incidence, and characteristics of the developmentally disabled, and resulting implications for physical education. Emphasis on adaptation of activities, methods, and program planning. Observation opportunities available.

****392. Physical Education for the Physically Disabled.** (1-2) Cr. 2. S. *Prereq: Psych 230.* Organization of an adapted physical education program. Study of specific disabling conditions in terms of etiology, description, and potential for movement and activity. Activities and specific exercises aimed at the rehabilitation of the individual.

455. Physiology of Exercise. (2-3) Cr. 3. F.S. *Prereq: Zool 156.* Physiological basis of human performance; effects of physical activity on body functions.

475. Physical Education Curriculum Design and Program Organization. (3-0) Cr. 3. F.S. *Prereq: 375.* Current practices and principles applied to curriculum development (K-12) and to problems of organization and administration of instructional and extracurricular programs in physical education.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

505. Research Laboratory Techniques in Exercise Physiology. (0-3) Cr. 1. *Prereq: 455 or equivalent course with basic laboratory experience.* Application and use of laboratory research equipment in exercise physiology, including operation, calibration, and use in selected situations.

520. The Social Analysis of Sport. (3-0) Cr. 3. *Prereq: 360, Soc 134.* Sociological analysis of sport with emphasis on sociological theory, sports structure, and function in modern industrialized society; the systems of sport in regard to their role structure; formal organization, and professionalization and its differentiation along social class, age, and sex.

521. Sport Psychology. (3-0) Cr. 3. *Prereq: 360, 3 courses in psychology.* Aspects of psychology which form a basis for understanding and explaining behavior in a sport context. Variables underlying individual as well as group performance will be analyzed. A critical analysis of current research literature.

523. Sex Roles and Sport. (W S 523) (2-0) Cr. 2. *Prereq: 360, 3 courses in sociology and/or psychology.* Analysis of the influence of sport on male and female sex role development. Survey of literature related to sport and sex role socialization. stereotyping, and conflict. Discussion of future issues and alternative roles.

540. Administration of Physical Education and Sport. (3-0) Cr. 3. *Prereq: 475 or 402.* Theory and practice of administration in physical education and sport; development of concepts related to the process of administration, types of administrative behavior, tasks and responsibilities of the administrator; evaluation of effectiveness of administration.

550. Advanced Physiology of Exercise I. (2-3) Cr. 3. *Prereq: 455.* Concepts and methodology in assessing neurological, muscular, cardiovascular, and respiratory adjustments to exercise.

551. Advanced Physiology of Exercise II. (2-3) Cr. 3. *Prereq: 455.* Analysis of factors affecting work capacity and performance. Human energy metabolism concepts and measurement.

560. Perceptual Motor Learning. (2-3) Cr. 3. *Prereq: 370, Psych 333 or equivalent.* Emphasis on theories of perceptual motor learning characteristics of the learner and the learning environment with implications for the design of learning settings and further research.

561. Movement, Motor Ability, and Motor Performance of Children. (2-0) Cr. 2. *Prereq: 284, Psych 230.* The physical development and characteristic reactions of children in relation to motor performance. Identification of special psychomotor needs of various age goups of children. All literature and theories applied to the physical education environmwent.

570. (DL 395) Adapted Physical Education. (2-3) Cr. 3. *Prereq: 375.* Graduate study in conjunction with P E 395. Additional readings, term project, and special examination required. May not be taken by students who have previously earned credit in P E 390 or 392 or 395.

590. Special Topics. Cr. 1 to 3.
A. Physical education
B. Leisure studies

591. Supervised Field Experience. (0-2 to 6) Cr. 1 to 4. *Prereq: 10 graduate credits in physical education and/or related areas.* Supervised on-the-job field experience in special areas.
A. Physical education
B. Leisure studies

593. Workshops. Cr. 1 to 3.
A. Physical education
B. Leisure studies

Courses for Graduate Students, major or minor.

615. Seminar. (1-3-0) Cr. 1 to 3.
A. Physical education
B. Leisure studies

699. Research. Cr. arr. *Prereq: 10 credits in education.*

Physics

Clayton A. Swenson, Chair of Department

The Graduate Faculty

Members: Anderson, Barnes, Beavers, Bowen, Carlson, Carr (Emeritus), Clem, Cook, Crawley, Danielson, Earls (Emeritus), Finnemore, Firestone, Fuchs, Grossman, Hammer, Harmon, Hill, Hodges, Jensen (Emeritus), Kernan, Kirkham (Emeritus), Klemm, Kliewer, Lamb, Lassila, Leacock, Legvold (Emeritus), Liu, Lynch, Parker, Peterson, Pursey, Rosenberg, Ross, Ruedenberg, Shelton, Spedding (Emeritus), Stanford, Stassis, Swenson, Vary, Weber, Williams, Willson, Wohn, Wolf, Young, Zaffarano

Associate Members: Lewis, Nolan

The department offers work for the degree Master of Science and for the degree Doctor of Philosophy with majors in physics, astrophysics, high energy physics, nuclear physics, and solid-state physics; and minor work to students majoring in other departments.

Facilities of the department and in the Ames Laboratory are available for both theoretical and experimental research.

Students with bachelor's degrees in physics or astronomy from other institutions ordinarily will qualify for graduate study here provided they have satisfactorily completed course work similar to that suggested for undergraduate physics majors at this University. In some cases, additional instruction at the intermediate level may be required.

The degree Master of Science in physics is offered both with and without thesis. In either case, the basic requirements are the same: at least 30 credits of acceptable graduate work must be cohpleted, not less than 21 of which must be in physics or astronomy and not less than 6 either from outside the department or in areas different from the student's major area. At least 15 of the credits in physics must be in courses at the 500 or 600 level exclusive of 595 and 699. Students choosing a degree with thesis may apply up to 8 credits of 699 but no credits of 595 toward the minimum 30 credits. Students choosing a degree without thesis should apply 1 credit per semester of 595, up to 2 credits, but may not apply any credits of 699 toward the minimum 30 credits.

Each candidate for the Doctor of Philosophy degree is required to teach one year of elementary physics. In addition to course work in the major area a candidate must take 12 minor credit hours outside this area, not less than 6 of which must be from other departments.

The Physics Department cooperates in the interdepartmental minor in Technology and Social Change. (See *Technology and Social Change.)*

Astronomy and Astrophysics (Astro)

Courses for Graduate Students, minor only

344, 345. Introductory Astrophysics. (3-0) Cr. 3 each. Yr. *Prereq: 344: Phys 222; 345: 344.* 344: The solar system. Astronomical techniques and coordinate systems. Observational aspects of stellar astronomy: spectral classification, variable stars, binary stars, star clusters. 345: Stellar astrophysics: structure and evolution of stars; origin and interpretation of stellar spectra. Interstellar matter, nebulae, galaxies, cosmology.

344L. Astronomy Laboratory. (0-6) Cr. 3. F. *Prereq: Credit or classification in 344.* Observational techniques and experiments in optical astronomy.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

510. Observational Astrophysics. (1-4) Cr. 3. Alt. F., offered 1981. *Prereq: 345.* Techniques of astronomical data acquisition, analysis, and interpretation as applicable in studies in photometry, spectroscopy, binary stars, parallax, and proper motion. Observing projects for gaining proficiency in the use of astronomical telescopes, instruments, and coordinate systems.

518. Radio Astronomy and Astrophysics (E E 518) (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 365 or E E 313.* Radio astronomy fundamentals; wave polarization and measurement; radio telescope receivers and antennas; wave propagation in plasmas; synchrotron emission; continuum and line spectra; physical conditions in radio sources.

550. Galactic and Extragalactic Astronomy. (3-0) Cr. 3. S. *Prereq: 345, Phys 322.* The interstellar medium, galactic structure, dynamics of external galaxies, evolution and classification of galaxies, extragalactic radio sources, quasars, cosmological models.

580. Stellar Evolution and Nucleosynthesis. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 345, Phys 322.* Solution of the equations of stellar structure, analytic approximations and theorems relating to equilibrium stellar models, survey of the results of numerical calculations of stellar evolution, nucleosynthesis in massive stars, final phases of stellar evolution, evolution of close binaries.

585. Radiative Transfer, Stellar Atmospheres, and Spectroscopy. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 345, Phys 322.* Basic methods of radiative transfer with applications in stellar interiors, stellar and planetary atmospheres. Theory and interpretation of astronomical spectra: line profiles; LTE and non-LTE line formation; interpretation of spectra observed at high resolution and low resolution; abundances, model atmospheres, and curves of growth.

590. Special topics. Cr. var.

595. Tutorial Astrophysics. Cr. var. *Prereq: Permission of instructor.* Individually directed study of research-level problems for students electing the nonthesis M.S. option in astronomy.

Courses for Graduate Students, major or minor

650. Advanced Seminar. (1-0) Cr. 1 each time taken. F.S. Topics of current interest in astronomy and astrophysics.

660. Advanced Topics in Astronomy and Astrophysics. Cr. 1 to 3 each time taken. F.S. Topics in stellar interiors and evolution, stellar atmospheres, interstellar matter, cosmology, solar physics, astronomical sources, and recent developments.

699. Research.

Physics (Phys)

Courses for Graduate Students, minor only

304. Thermal Physics. (3-0) Cr. 3. F. *Prereq: 222, Math 266 or 371.* Concepts of termperature, entropy, and other characteristic thermodynamic functions, with application to macroscopic properties of matter. The laws of thermodynamics; heat engines, efficiencies. Kinetic theory and the Maxwell velocity distribution. Introduction to statistical mechanics, including quantum statistics. Application to black body radiation, crystalline vibrations, magnetic ions in solids, electronic heat capacity of metals.

311. Intermediate Laboratory. (0-6) Cr. 3 each time taken. S. *Prereq: 322 or 324.* Experiments in classical and modern physics performed independently by each student.

361. Classical Mechanics. (4-0) Cr. 4. F. *Prereq: 221, Math 266 or 371.* Newtonian mechanics, including linear forced oscillations, central forces and orbital motion, moving reference frames; Lagrange's equations; rotation of rigid bodies; theory of small vibrations.

364. Electricity and Magnetism I. (3-0) Cr. 3. S. *Prereq: 222, Math 385.* Electrostatics, electromagnetism and relativity, magnetostatics, potential theory.

365. Electricity and Magnetism II. (2-0) Cr. 2 F. *Prereq: 364.* Time variation of electromagnetic fields; radiation; interaction with matter; interference and diffraction; waveguides and cavities.

396. Optics. (3-0) Cr. 3. S. *Prereq: 321 or 324.* Physical optics: interference, diffraction, scattering, polarization, coherence, topics in quantum optics.

447. Modern Physics. (4-0) Cr. 4. F. *Prereq: 222, Math 266 or 371.* Primarily for graduate students in other fields who desire a fast-paced presentation. A concise treatment of some important topics from classical mechanics and electromagnetism; Schroedinger formulation of quantum mechanics and its application to the hydrogen atom, the helium atom, and electrons in a periodic lattice; the semiclassical theory of emission and absorption of radiation.

480. Quantum Mechanics. (3-0) Cr. 3. F. *Prereq: 322, Math 385.* A systematic development of quantum mechanics, including differential and operator solutions of the Schroedinger equation, matrix formulation of eigenvalue problems, angular momentum, and perturbation theory.

481. Atomic and Molecular Physics. (2-0) Cr. 2. S. *Prereq: 480.* Interaction of electrons with the electromagnetic field, Zeeman effect, Stark effect, hyperfine interaction; helium atom, many-electron atoms, Hartree equation; hydrogen molecule, molecular specific heats, molecular bonding, molecular spectra; radiation of atoms, line width, induced absorption and emission.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Introductory Research Seminar. (1-1) Cr. 1. F. Discussion by research staff of their research areas, expected thesis research work, and opportunities in the field. For graduate physics majors only.

511. Solid State Physics. (3-0) Cr. 3. S. *Prereq: 304, 322.* Free electron model; crystal symmetry; band theory of solids; transport properties; Fermi surface; phonons; semiconductors; magnetism; superconductivity.

524. Introductory Nuclear Physics. (3-0) Cr. 3. F. *Prereq: 447 or credit or classification in 480.* Basic properties of nuclei and radioactive decay. Nuclear detectors and accelerators. Phenomenology of nuclear forces and nuclear models.

525. Nuclear Physics. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 524.* Shell and collective aspects of nuclear structure. Nuclear reactions and scattering processes.

528. Atmospheric Physics. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 322, 304, 361, and 364.* Physics of fluids as applied to the atmosphere: equations of motion, conservation laws; atmospheric waves, small to planetary scale; observational techniques; lower and upper atmospheric structure and processes.

531. Statistical Mechanics. (3-0) Cr. 3. F. *Prereq: 304, Math 465, credit or classification in Math 426 or 365.* Thermodynamic properties of systems of many particles obeying Boltzmann, Fermi-Dirac, and Bose-Einstein statistics; microcanonical, canonical, and grand canonical ensembles and their application to physical problems; density matrices; introduction to phase transitions; kinetic theory; fluctuations and noise.

537. High Energy Physics. (3-0) Cr. 3. S. *Prereq: 480.* Experimental methods; conservation laws and invariance principles; weak, electromagnetic and strong interactions; quark model, symmetry schemes, and dynamical models.

541. General Relativity. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 361 or Math 465.* Tensor analysis and differential geometry developed and used to formulate Einstein field equations. Schwarzschild and Kerr solutions. Other advanced topics such as alternate gravitational theories, attempts at unified field theories, cosmology.

564. Advanced Classical Mechanics. (3-0) Cr. 3. F. *Prereq: 361, Math 426, 465.* Variational principles, Lagrange's equations, Hamilton's canonical equations, canonical transformation, Hamilton-Jacobi theory, infinitesimal transformations, classical field theory.

571, 572. Advanced Electricity and Magnetism. (3-0) Cr. 3 each. 571: S.; 572: F. *Prereq: 571: 365, Math 426; 572: 571.* 571: Electrostatics, magnetostatics, boundary value problems, Maxwell's equations, electromagnetic fields and wave phenomena in macroscopic media, simple radiation systems, wave guides. 572: Relativistic physics: special theory of relativity, relativistic particle and electromagnetic field dynamics, radiation by moving charges, collisions between charged particles, bremsstrahlung, radiation.

590. Special Topics. Cr. var. *Prereq: Permission of instructor.* Topics of current interest in high energy physics, nuclear physics, solid state physics, and atmospheric physics. Topics in other areas offered periodically, depending upon current staff interests.

591, 592. Quantum Physics. (3-0) Cr. 3. each. Yr. *Prereq: 591: 480; 592: 591.* Schroedinger theory, representations, approximation methods, time-dependent problems, elementary scattering theory.

595. Tutorial Physics. Cr. var. *Prereq: Permission of instructor.* Individually directed study of research-level problems for students electing the nonthesis M.S. degree option.

Courses for Graduate Students, major or minor

611, 612. Quantum Theory of Solids. (3-0) Cr. 3 each. Yr. *Prereq: 611: 511, 592; 612: 611.* 611: Electronic band structure; phonons; X-ray, neutron, and electron scattering; dielectric response; Boltzmann equation. 612: Optical properties; magnetism; superconductivity.

624. Theory of Nuclear Reactions. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 592 and 524.* Theories of nuclear reactions, including compound nuclei, direct reactions, and multiple scattering theory.

625. Theory of Nuclear Structure. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 592 and 525.* Current theories of nuclear structure, including microscopic and collective aspects.

637, 638. Elementary Particle Physics. (3-0) Cr. 3 each. Alt. Yr., offered 1981-82. *Prereq: 637: 537, 592; 638: 637.* Properties of elementary particles and reactions, SU(3) and quark model, relativistic quantum mechanics of particles with any spin, S-matrix theory, quantum electrodynamics and quantum chromodynamics, Regge theory and current algebra.

650. Advanced Seminar. (1-0) Cr. I each time taken. F.S. Topics of current interest.
A. Nuclear Physics
B. Solid State Physics
C. High Energy Physics

660. Advanced Topics in Physics. Cr. 1 to 3 each time taken. F.S. Courses on advanced topics and recent developments.
A. Nuclear Physics
B. Solid State Physics
C. High Energy Physics

674. Applications of Group Theory to Physics: Solid State Physics. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 592.* Theory of groups and group representations; point, space, and rotation groups; applications to molecular and crystal structures, crystal field and spin-orbit interactions, energy bands and phonon dispersion relations.

675. Applications of Group Theory to Physics: Nuclear and High Energy Physics. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 592.* Theory of Lie groups, Lie algebras, and their representations; detailed expositions of the three-dimensional rotation group, Lorentz group, Poincaré group, and SU(3); survey of other Lie groups of physical importance; applications to nuclear shell structure, angular correlation theory, helicity states, relativistic partial wave analysis, elementary particle properties.

681, 682. Quantum Mechanics. (3-0) Cr. 3 each. Alt. Yr., offered 1982-83. *Prereq: 681: 592; 682: 681.* Angular momentum theory, second quantization, many-particle theory, photons and light scattering, relativistic wave equations with emphasis on Dirac's equation, introduction to quantum electrodynamics.

699. Research.

Plant Pathology, Seed and Weed Sciences

Abraham H. Epstein, Chair of Department

The Graduate Faculty

Members: Browning, Burris, Dunleavy, Fawcett, Hill, Hodges, Isely, McGee, McNabb, Norton, Simons, Staniforth, Stewart, Tachibana, Tiffany, Vakili

Associate Members: Braun, Clark, Epstein, Foley, Martinson, Mullen, Nyvall

The department offers studies for the degrees Master of Science and Doctor of Philosophy with a major in plant pathology, and minor work for students majoring in other departments. A Master of Science nonthesis option is available. A student majoring in plant pathology may specialize in seed science or weed science.

Students entering graduate programs in the department need a sound background in the physical, biological, and mathematical sciences as well as adequate preparation in English.

For the degree Doctor of Philosophy, the requirement in foreign language or its alternative is established by the student's advisory committee.

Courses for Graduate Students, minor only

407. Principles of Plant Pathology. (P M 407) (2-3) Cr. 3. F.S. *Prereq: 8 credits in botany including 207.* Braun. Principles underlying the nature, diagnosis, and management of plant diseases.

416. Forest Pest Management. (For 416, Ent 416, P M 416) (2-3 or 3-6) Cr. 3 or 5. S. *Prereq: 8 credits in biological sciences, including Bot 207.* McNabb, Hart. 3-credit course: Nature of forest- and shade-tree pests; agents of deterioration of wood products. Separate laboratory for students in resource management or forest products. 5-credit course: An additional lecture and arranged laboratory using integrated case studies and computer simulations in the evaluation and economic analysis of protection and pest management problems; physical agents of tree damage; weekend field trips. Fee for field trips.

418. Weed Control with Herbicides. (P M 418) (2-0) Cr. 2. S. *Prereq: 216, Bot 310 or 320.* Staniforth. Principles and practices of modern weed control with emphasis on herbicide technology; herbicide selectivity, mode of action, crop phytotoxicity and the fate of herbicides in the environment; weed biology and ecology as related to the efficacy of herbicides.

438. Seed Biology. (agron 438) (2-3) Cr. 3. Alt. F., offered 1982. *Prereq: Bot 310 or 320.* Burris, McGee. Physiological aspects of seed development, maturation, longevity, and germination; seed pathology; ecological and agricultural implications of seed biology.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

509. Plant Virology. (Micro 509) (2-6) Cr. 4. Alt. S., offered 1982. *Prereq: 407, Bot 404, B B 406, Chem 211.* Hill. Plant viruses and the diseases they cause. Emphasis on epidemiology and control. Structure, function, and biochemical-biophysical properties of plant viruses.

541. Epidemiology and Control of Plant Diseases. (3-0) Cr. 3. F. *Prereq: 407 or 416, Agron 421 or For 501 or Hort 525.* Browning. Environmental and genetic control of disease development; theories of managing resistance genes and cultural practices to maximize natural control processes.

544. Advanced Forest Pest Management. (For 544, Ent 544) (2-3) Cr. 3. Alt. F., offered 1982. *Prereq: 416.* McNabb, Hart. Systems analysis approach to the management of forest and shade-tree pests; planning of research on such pests. Fee for field trips.

574. Plant Nematology.)2-2) Cr. 3. F. *Prereq: 407 or 416.* Norton. Morphology, anatomy, life cycles, and local distribution of commonly encountered plant-parasitic nematodes; symptom expression; control.

576. Bacterial Diseases of Plants. (2-3) Cr. 3. Alt. F., offered 1982. *Prereq: 407 or 416, Bact 300.* Braun. Characteristics of prokaryotic plant pathogens and the diseases they cause. Laboratory emphasizes techniques used in studying bacterial plant pathogens.

590. Special Topics. Cr. 1 to 3 each time taken. *Prereq: 10 credits in biological sciences, permission of instructor.*
A. Plant Pathology
B. Seed Science
C. Weed Science

591. Advanced Plant Pathology. (3-3) Cr. 4. Alt. S., offered 1982. *Prereq: 407 or 416.* Martinson. Plant disease concepts and processes; representative plant diseases with emphasis on fungus diseases, ecology of fungus pathogens, and literature review.

Courses for Graduate Students, major or minor

691. Clinical Plant Pathology. (0-6) Cr. 2 each time taken. Alt. SS., offered 1982. *Prereq: 541, 591, permission of instructor.* Nyvall. Diagnosis of plant diseases, isolation and identification of pathogens, clinical experience, plant disease survey, detection and evaluation methods.

692. Plant Disease Physiology. (2-3) Cr. 3. Alt. S., offered 1983. *Prereq: 407 or 416, Bot 320.* Martinson. Physiological and morphological aspects of parasitism, host response to pathogens, physiology of resistance mechanisms, and specificity in disease interactions.

698. Seminar. Cr. I. F.S.
A. Plant Pathology
B. Seed Science
C. Weed Science

699. Thesis and Dissertation Research. Cr. var.
A. Plant Pathology
B. Seed Science
C. Weed Science

Political Science

Victor A. Olorunsola, Chair of Department

The Graduate Faculty

Members: Boles, Hadwiger, Kihl, Olorunsola, Parks, Rasmussen, Schmidt, Talbot, Wiggins

Associate Members: Dorfman, Hutter, Lee, McCormick, Maney, Moses, Shelley, Wessel, Whitmer

The department offers work for the degree Master of Arts with major in political science and minor work to students majoring in other departments.

The program is designed to enable its graduates to engage in governmental research, enter public service or private industry, pursue further graduate study, or teach. Both thesis and nonthesis options are available. Within either option, a specialization in public administration is possible. This department also has a joint Juris Doctor/Master of Arts Program with the Law School of Drake University. In addition, graduate students may wish to work for certification for high school or junior college teaching.

The department also offers a Master of Public Administration. This is a professional degree in public administration. It is designed to provide interested students with the training necessary to operate within a public bureaucracy and organization. The M.P.A. degree requires 39 semester credit hours.

Brochures setting forth the detailed requirements for the degrees within each option, for the M.A./J.D. degree, and the M.P.A. degree may be obtained from the political science office.

A usual prerequisite for major graduate work in the department is the completion of at least 15 semester credits in political science. The Graduate Record Examination (for both aptitude and advanced examinations) is strongly recommended.

Each student entering the Master of Arts program in political science is expected to have completed one year of a foreign language (equivalent to eight semester credits) and a course in basic statistics (equivalent to Stat 101). If this has not been done, the student may remedy the deficiency by passing equivalent courses, for which no graduate credit will be received.

In addition, each student must complete one of the following requirements:

(1) Language — Two years of undergraduate instruction (including the one year of foreign language provided above) in a single language, with grades averaging 2.7 (on a 4.0 scale); or, a passing grade in the Educational Testing Service examination.

(2) Statistics — Successful completion of Stat 401. Stat 402 is recommended, but not required.

These requirements are only the basic minima. The student's program of study committee will decide if additional work, in either language or statistics, is necessary.

The department also offers a Master of Arts program, with no language requirement and a choice of a thesis or an internship requirement, to those students who wish to prepare for, or are employed in, government service.

The department cooperates in the interdepartmental programs of Industrial Relations, Transportation Planning, and Technology and Social Change. (See Index.)

Courses for Graduate Students, minor only

410. Iowa Government and Politics. (3-0) Cr. 3. F. *Prereq: 215.* Wiggins. Analysis of Iowa government and politics, focusing upon major institutions of government: political parties; interest groups, legislature, supreme court and chief executive. Role of municipalities and counties as local units of Iowa government.

411. Public Policy and Local Government. (3-0) Cr. 3. Alt. S. *Prereq: 310.* Boles. Analysis of structure, administration, and legal basis of the county, township, and special districts, such as school and drainage districts. Evaluation of local governmental functions, such as education, welfare, highways, including problems of taxation and finance. Effects of population shifts on future of local governments.

420. Constitutional Law. (3-0) Cr. 3. F. *Prereq: 215, junior classification.* Boles. Development of the United States Constitution through judicial action; influence of public law and judicial interpretations upon American government and society.

421. Civil Liberties. (3-0) Cr. 3. S. *Prereq: 215; junior classification.* Boles. American constitutional and statutory guarantees of civil rights. First Amendment rights of conscience and freedom of expression as well as rights of defendants. Application of equal protection of laws to minority groups. Various reform proposals.

422. International Law. (3-0) Cr. 3. S. *Prereq: 215 or 251; junior classification.* Dorfman. Develoment of the principles of international law of peace and war; analysis of theories concerning its nature and fundamental conceptions; its relation to national law; problems of international legislation and codification.

430. Development of Political Thought: Classical Thought through Early Contract Theory. (3-0) Cr. 3. F. *Prereq: 6 credits in political science, philosophy, or European history.* Shakeshaft. Major concepts in original texts of classical, medieval, and early modern authors: friendship, community, man's basic nature; natural law; force; society outside the political order. Emergence of the modern state and sovereignty in the transition to secular authority. Relevant historical considerations; contemporary applications. Plato through Hobbes.

431. Development of Political Thought: Modern and Contemporary Political Thought. (3-0) Cr. 3. S. *Prereq: 6 credits in political science, philosophy, or European history.* Shakeshaft. Original texts and relevant historical considerations. Human nature and its influence on contract theory; private rights; differing connotations of liberty; sovereignty; constitutionalism; dialectical materialism; bureaucracy; law; democractic theory. Locke through Marx, Mill, and contemporary authors.

433. American Political Thought. (3-0) Cr. 3. S. *Prereq: 6 credits in political science or in American history.* Talbot. Review of major political concepts and theorists in American political history. Analysis of current concepts in U.S. political thought, and their possible impacts on our political institutions.

443. The U.S. and Latin America. (3-0) Cr. 3. Alt. S. *Prereq: 241 or 251 or 343.* Schmidt. Analysis of the political consequences of Latin American dependency and growth of nationalism. Monroe Doctrine, aid, revolution, nationalization, multinational corporations.

444. Government and Politics of the Soviet Union. (3-0) Cr. 3 F. *Prereq: 241.* Moses. Analysis of Soviet political system and society. Organization and functioning of the Communist Party and its role in development of the Soviet Union. Problems of continuity and change in structure, processes, and policies of the Soviet political system.

447. Development in African Politics. (3-0) Cr. 3. Alt. S. *Prereq: 241 or 340 or 347.* Olorunsola. Examination of various developmental problems in African politics and policies; e.g., economic growth, equity, rural-urban relationships, political stability, integration, and institution building; the degree to which development is at the core of African aspirations.

448. The Military and Politics. (3-0) Cr. 3. Alt. F. *Prereq: 241.* Olorunsola. Type and nature of civil military relations, why and how the military intervenes in politics, theories of the military and development. Case studies of developmental performance of the military, possibilities of military disengagement.

451. Asia in World Politics. (3-0) Cr. 3. Alt. S. *Prereq: 241 or 251.* Kihl. International politics of Asia; emphasis on shifting power balance, role of major powers, security dilemma, foreign policies of small nations, prospect for regional integration.

452. Comparative Foreign Policy. (3-0) Cr. 3. F. *Prereq: 251.* Kihl, McCormick. Various theoretical approaches to explain foreign policymaking and behavior through the use of case studies of selected nations.

453. International Organizations. (3-0) Cr. 3. S. *Prereq: 251.* Kihl. Private and public organizations such as the United Nations, other specialized agencies, and multinational organizations, and their influence on our daily lives.

457. Soviet Foreign Policy. (3-0) Cr. 3. S. *Prereq: 251.* Moses. Basic factors determining formulation and execution of Soviet foreign policy. Analysis of process and development of foreign policy since 1945, emphasizing the post-Stalin period in Europe, in intrabloc relations, and in the Third World.

464. Political Parties and Interest Groups in American Politics. (3-0) Cr. 3. S. *Prereq: 215.* Structure and operations of interest groups and parties; relationships between parties and interest groups and functions they perform in the political system.

471. Administrative Politics. (3-0) Cr. 3. F. *Prereq: 215.* Wessel. The regulatory process; structure and politics of regulatory agencies; political interactions of agencies, legislators, interest groups, and the legal system.

475. Techniques of Public Administration. (3-0) Cr. 3. S. *Prereq: 371.* Major techniques involved in communications, finance and personnel administration; intergovernmental relations and policy analysis in agencies of the federal, state, and local government.

476. Administrative Law. (3-0) Cr. 3. S. *Prereq: 215; junior classification.* Boles. Constitutional problems of delegation of governmental powers, elements of fair administrative procedures, judicial control over administrative determinations.

478. Development Administration. (3-0) Cr. 3. Alt. F. *Prereq: junior classification.* Olorunsola, Wessel. Theories and practices of the administration of development. Role of bureaucracy in system maintenance, control and change in developing states. Case studies of some development projects in developed and developing countries.

480. Ethics and Public Policy. (3-0) Cr. 3. S. *Prereq: 6 credits in political science.* Talbot. Major ethical concepts in U.S. political philosophy. The controversy over public versus private morality in political policy-making. Analysis of public decision-making case studies, with particular emphasis on the ethical consideration involved therein. Major proposals and legislation related to improving the quality of ethical criteria and decisions in public policy-making.

481. World Food and Development Assistance Politics. (3-0) Cr. 3. F. *Prereq: 6 credits in political science.* Talbot. International and U.S. food policies since the World Food Conference, relative to food aid, nutrition, food security, and commodity agreements. Emphasis on development assistance concepts and policies, multilateral and bilateral. Analysis of the decision-making process within and between world food and development-assistance institutions, and within the U.S. Government. Proposals for their improvement made by international and national commissions and agencies.

482. Environmental and Land Use Politics and Policies. (3-0) Cr. 3. S. *Prereq: 6 credits in political science.* Talbot. Major ideologies relating to conservation and ecology. Primary emphasis on the policy-making process in U.S. national and state governments, with principal application to environmental and land-use policies. Major proposals for improvement in policy content and process.

484. Farm and Small Town Development Policies. (3-0) Cr. 3. F. *Prereq: 215.* Hadwiger. Major policies, political institutions, intergovernmental relations, and significant groups and coalitions active in non-metropolitan environments. Policy arenas include education, poverty, housing, recreation, conservation and environment, research and extension, manpower, agriculture and farm policies.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501. Political Research. (3-2) Cr. 3. F. *Prereq: 15 credits in political science.* Hutter. Principles of scientific, empirical research applied to political data and public policies. Research design, ethics, role of theory, types and sources of data. Survey research, voting analysis, program evaluation, computer utilization, interviewing, review of algebra and the role of statistical techniques in research.

510. State Government and Politics. (3-0) Cr. 3. Alt. F. *Prereq: 310.* Wiggins. Comparative analysis of state political systems. Role of interest groups, political parties, legislatures, courts, and governors in state politics. Possible determinants of public policy outputs at the state level.

511. (411 DL) Public Policy and Local Government. (3-0) Cr. 3. Alt. S. *Prereq: 310.* Boles. Graduate study in conjunction with 411. Not available for credit for students having taken 411.

512. Urban Politics and Administration. (3-0) Cr. 3. F. *Prereq: 311.* Maney. Structure and process of urban politics and the metropolitan political systems; problems in urban management and intergovernmental relations; theoretical perspectives on urban politics and policy.

525. (425 DL) Public Law and Public Policy. (3-0) Cr. 3. Alt. S. *Prereq: 320 or 420.* Boles. Graduate study in conjunction with 425. Not available for credit for students having taken 425.

531. (431 DL) Development of Political Thought: Modern and Contemporary Political Thought. (3-0) Cr. 3. S. *Prereq: 430.* Shakeshaft. Graduate study in conjunction with 431. Not available for credit for students having taken 431.

543. Single-Party States. (3-0) Cr. 3. S. *Prereq: 6 credits in comparative politics.* Moses. Internal dynamics of single-party states. Analysis of policy-making process, role of ideology, party membership, elite recruitment and promotion, and factors influencing prospects and directions of political change in a single-party state.

547. Political Leadership and Elites. (3-0) Cr. 3. S. *Prereq: 6 credits in political science.* Schmidt. Various forms of leadership and leader-follower relations. Obligations, exchanges, incentives, coercion, corruption, bossism in both the U.S. and foreign experience.

549. Comparative Political Behavior. (3-0) Cr. 3. Alt. F. *Prereq: 305 or 405.* Rasmussen. Empirical analysis of political behavior in cross-national perspective, including activist participation, level of political sophistication, cleavage structures and voting, role of partisan identification.

552. (452 DL) Comparative Foreign Policy. (3-0) Cr. 3. F. *Prereq:* 251. Kihl, McCormick. Graduate study in conjunction with 452. Not available for credit for students having taken 452.

559. International Relations Theory. (3-0) Cr. 3. S. *Prereq: 6 credits in international studies.* Kihl, McCormick. Review, analysis, and application of recent theoretical attempts to order systematically the field of international relations, especially lateral pressure, cyclical phenomena, decision making, and imperialism.

560. Legislative Behavior. (3-0) Cr. 3. Alt. S. *Prereq: 6 credits in American government.* Wiggins. Principles, procedures, and problems of the legislative process. Structure and organization of state legislatures and the U.S. Congress.

561. The Chief Executive. (3-0) Cr. 3. S. *Prereq: 6 credits in American government.* Hadwiger. Legal and political forces influencing the U.S. president, governors, and other governmental executives in decision making, developing and administering programs of government, leading public opinion, and influencing legislation.

571. Organizational Theory in the Public Sector. (3-0) Cr. 3. F. *Prereq: 6 credits in political science.* Wessel. Major theories of administrative organization, including motivations of administrators and organizations, comparisons of organizational arrangements, factors affecting organizational arrangements, and formal and informal decision-making structures.

572. Public Budgeting and Financial Management. (3-0) Cr. 3. Alt. S. *Prereq: 6 credits in political science.* The process of public budgeting. Alternative budget systems including taxation, the appropriation process, program evaluation, and debt and risk management at federal, state, and local levels.

573. Public Personnel Administration. (3-0) Cr. 3. Alt. S. *Prereq: 6 credits in political science.* Recruitment, retention, and development of employees; merit systems, collective bargaining, and greivance procedures.

574. Methods of Policy and Program Evaluation. (3-0) Cr. 3. S. *Prereq: 9 credits in political science.* Lee. Integration, application, and utilization of public administration and public policy concepts in the interpretation of results and effectiveness of public programs and the prediction of consequences for policymakers and administrators.

576. (476 DL) Administrative Law. (3-0) Cr. 3. S. *Prereq: Graduate classification.* Boles. Graduate study in conjunction with 476. Not available for credit for students having taken 476.

578. (478 DL) Development Administration. (3-0) Cr. 3. Alt. F. *Prereq: Graduate classification.* Olorunsola, Wessel. Graduate study in conjunction with 478. Not available for credit for students having taken 478.

580. (480 DL) Ethics and Public Policy. (3-0) Cr. 3. S. *Prereq: 6 credits in political science.* Talbot. Graduate study in conjunction with 480. Not available for credit for students who have taken 480.

590. Special Topics. Cr. 2 to 5 each time taken. F.S. *Prereq: 15 credits in political science, written permission of instructor.*

A. American Political Institutions
B. Public Law
C. Political Theory and Methodology
D. Comparative Government
E. International Relations
F. Political Parties and Policy Formation
G. Public Administration and Public Policy
I. Internship
T. Teaching Preparation

591. Seminar in the Teaching of American Government. (3-0) Cr. R. F. Preparation for college teaching. Required of graduate students who are, or plan to become, teaching assistants in 215.

599A. Research.

599B. Creative Component.

Courses for Graduate Students, major or minor

610. Graduate Seminars. (3-0) Cr. 3 for each seminar. F.S. *Prereq: 15 credits in political science.*
A. American Political Institutions
B. Public Law
C. Political Theory and Methodology.
D. Comparative Government
E. International Relations
F. Policy Process
G. Public Administration and Public Policy

Professional Agriculture

(Interdepartmental Program)

Donald G. Woolley, Chairman, Supervisory Committee

Supervisory Committee: C. E. Anderson, M. D. Boehlje, R. L. Willham

The major in professional agriculture is an off-campus program leading to the degree Master of Agriculture. It is available to students who wish to pursue graduate study in agriculture without taking formal course work on campus. The program is considered to be a terminal master's degree. Those who major in professional agriculture are required to take a minimum of two courses in each of three disciplines and complete 24 semester credits of formal course work, as well as 4 semester credits for a creative component, and 4 semester credits of worushops. Courses are offered in agricultural mechanization, agronomy, animal science, and economics. Specific courses offered in the program and the location of the off-campus teaching sites may be obtained from the departmental course listings and by contacting the supervisory committee.

As mentioned above, a minimum of four credits of creative component experience is required. A thesis option is not available. The creative component is a demonstration of independent creativity with a written report of laboratory, field, or library research acceptable to the student's program of study committee. Four workshops of one credit each are also required. The workshop in applied statistics is mandatory. Two of the workshops must be taken on campus.

The program of study committee in consultation with the student will determine the courses to be taken and the acceptability of transfer credits and on-campus course work. The major professor should be selected from the discipline where a concentration of course work will be taken.

Students who wish to pursue this off-campus major must meet the same admission requirements as other students seeking admission to graduate study.

For additional information students should communicate with the supervisory committee.

Professional Studies in Education

J. Stanley Ahmann, Chair of Department

The Graduate Faculty

Members: Ahmann, Bath, Beavers, Breiter, Brown, Charles, Dilts, Ebbers, Engel, Glass, Gowan, Hopper, Howe, Hunter, Kizer, Kniker, Lagomarcino, Manatt, Netusil, Pellegreno, Reschly, Simonson, Smith, Thomas, Warren, Wilson

Associate Members: Abelson, Barnhart, Baum, Beard, Boyles, Canute, Deems, Downs, Duffelmeyer, Goering, Hart, Henney, Huba, Jones, Keller, Kelly, Lawrence, Littrell, McNally-Jarchow, Miller, Schloerke, Stow, Sweeney, Volker, Zbaracki

Professional studies offers work for the degrees Master of Science, Master of Education, and Doctor of Philosophy with major in education and minor work to students taking major work in other departments. Within the education major a student may specialize in adult and extension education; educational administration; counselor education; higher education; historical, philosophical, and comparative studies in education; research and evaluation; curriculum and instructional media. The master's degree is the highest degree awarded in the elementary education, learning disabilities, and physical education areas of specialization.

Prerequisite to major graduate work in education is preparation substantially equivalent to the completion of one of the undergraduate curricula in education offered at Iowa State University, or graduate preparation in a discipline to be used as a teaching field in a community college or university, and adequate proof that the student ranks above average in scholastic ability and promise of professional competence.

The foreign language requirement, if any, for the Ph.D. degree will be determined by the student's program of study committee. If no foreign language is required, the total program must consist of a minimum of 78 semester hours, at least 16 of which must be earned outside the area of specialization. Research tools such as statistics and research methods may not be included in the 16 hours. Should foreign langugage be included, the program of study committee may adjust the minimum program requirement downward but in no instance may the required credit be less than 72 semester hours. Students whose native language is not English may substitute competence in English.

Other graduate programs related to education (including General Graduate Studies) may be planned for students on the basis of previous education and experience as well as future plans and needs. Students should refer to Agricultural Education, Home Economics Education, Industrial Education, Physical Education, and General Graduate Studies or to graduate-level course offerings within other departments.

Adult and Extension Education (Ad Ed)

John P. Wilson, Acting Section Leader

Course for minor graduate credit only

469. Introduction to Adult and Extension Education. (3-0) Cr. 3. F. *Prereq: 9 credits in education or related areas.* An overview of adult and extension education; its development, organizations, objectives, programs, and procedures. Designed for prospective extension agents and other adult educators.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

536. Foundations of Adult Education. (3-0) Cr. 3. F.SS. *Prereq: 469.* A study of the modern practice of adult education from the perspective of its history, philosophy, and literature.

537. Teaching in Adult Education. (4-0) Cr. 4. S.SS. *Prereq: 469 or 536.* Instruction and learning; theory, methods and techniques. Development of approaches for teaching adults.

538. Community and Adult Education. (3-0) Cr. 3. S. *Prereq: 536.* Application and procedures adult educators utilize in the development of community based education programs. Community education concepts, community needs, resources, leadership, and services.

539. Program Development in Adult and Extension Education. (3-0) Cr. 3. F.SS. *Prereq: 536.* Principles, models and evaluation of program planning processes.

590. Special Topics. Cr. 1 to 6. *Prereq: 9 credits in adult and extension education.*

591. Practicum/Internship. Cr. 1 to 6. *Prereq: 9 credits graduate work in adult and extension education.* Practicum or internship designed for work exposure in adult and extension education. Examples include: continuing education centers, community colleges, extension offices, training divisions, etc.

593. Workshop. Cr. 1 to 3. *Prereq: 536.* Workshops designed to provide intensive, concentrated, and experience-oriented exposure to a special adult and extension education topic.

595. Colloquium in Adult and Extension Education. Cr. 1 to 3. *Prereq: 6 credits in education.* Offered when demand warrants.
A. Adult Basic Education
B. Adult Counseling
C. Educational Gerontology
D. Dynamics of Instructional Groups
E. International Adult Education
F. Adult Training in Life/Career Planning
G. Nontraditional Education
H. Philosophy of Adult Education
I. Training Skills
J. Administration of Adult Vocational Education

Courses for Graduate Students, major or minor

601. Theory Building in Adult Education. (3-0) Cr. 3. *Prereq: 536, 537, 538, 539.* Examination of what is theory and developing theory in adult education.

615. Seminar. (1-0) Cr. 1-3. F.S.SS. *Prereq: 10 credits in adult and extension education, permission of instructor.* Group study and discussion on student and staff research in adult and extension education.

699. Research. Cr. arr. F.S.SS. *Prereq: 10 credits in adult and extension education, permission of instructor.*

Counselor Education (Co Ed)

Gordon Hopper, Section Leader

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

530. Human Interaction and Learning. (3-0) Cr. 3. F.S.SS. *Prereq: 8 credits undergraduate education, sociology, or psychology.* An overview of research, theory, and conditions that facilitate behavioral change in individuals and within institutions. Classroom instruction and assignments are planned so students can relate their individual needs to professional role expectations.

532. Guidance in the Elementary School. (2-0) Cr. 2. F.SS. *Prereq: 8 credits undergraduate education, sociology, or psychology.* Introduction to current counseling, coordinating, and consulting practices as they relate to students, parents, and professionals in the elementary school.

Courses for Graduate Students, major or minor

534. Development, Management and Evaluation in Guidance. (2-0) Cr. 2. S. *Prereq: Co Ed 530.* Proactive involvement in defining, delivering, scheduling, and evaluating guidance services in a school setting. Leadership styles, public relations, and identifying and working within the school and community power structure in relation to establishing and redefining guidance service objectives. Methods of evaluating the impact of guidance services.

538. Cross Cultural Issues in Counseling. (2-0) Cr. 2. Alt. SS., offered 1982. *Prereq: Co Ed 530.* Biases of self, others, and institutions with strategies for change.

551. Occupational Choice and Development. (2-0) Cr. 2. F. Alt. SS., offered 1983. *Prereq: Co Ed 530.* Career development and choice factors influencing career choice, classification systems, types of informational materials, putting informational materials to use in various settings.

555. Use of Assessment Instruments in Counseling and Consulting. (2-0) Cr. 2. S. Alt. SS., offered 1982. *Prereq: Co Ed 530, Re Ed 550.* Measurement principles involved in applying and interpreting data gathered by assessment instruments, types of assessment instruments available, selection of appropriate instruments for use with different populations. Includes supervised experience using different modes of relating assessment data to students, faculty, and parents.

560. Theories of Counseling. (2-0) Cr. 2. F.SS. *Prereq: 530.* Current approaches to counseling for facilitation of choice and/or behavorial change.

561. Counseling Techniques: Adolescent and Young Adult. (2-1) Cr. 2. F.SS. *Prereq: Concurrent enrollment in 560 or Co Ed 560.* Application of theory to practice through exposure to didactic and laboratory work with clients. The laboratory portion stresses skill building in listening and responding, identifying barriers to change and planning intervention strategies.

565. Counseling Techniques: Preadolescents. (2-0) Cr. 2. F. *Prereq: Credit or classification, Co Ed 560.* Applied use of role playing, fantasy, classroom groups, relaxation, and other specific techniques that can be utilized as a means for assisting the preadolescent with self understanding, problem solving and other developmental concerns.

570. Theories of Group Procedures. (2-0) Cr. 2. S.SS. *Prereq: Co Ed 560.* Current group counseling approaches for facilitation of choice and/or behavioral change.

571. Laboratory Experience in a Counseling Group. (0-2) Cr. 1. F.S. *Prereq: Co Ed 570.* Enrolled students will be participants in a counseling group. Offered on a satisfactory-fail basis only.

580. Practicum in Counseling. (2-8) Cr. 4. F.S. *Prereq: Co Ed 561 or 565.* Designed for students who desire counseling experience in a nonschool setting. Practicum experience can be arranged at urban centers, detention facilities, MDTA centers, vocational rehabilitation centers, etc.

581. Practicum in Secondary School Counseling. (2-8) Cr. 4. F.S. *Prereq: Co Ed 561.* Placement in a secondary and /or junior high school. The practicum student will perform various role functions expected of the school counselor. Emphasis on individual and group counseling functions.

582. Practicum in Elementary School Counseling. (2-8) Cr. 4. F.S. *Prereq: Co Ed 565.* Placement in an elementary school..Counseling students, consulting with teachers and parents and coordinating activities that enhance student development and growth both in the cognitive and affective domains.

590. Special Topics. *Prereq: 10 graduate hours in counselor education.*
A. Creative Component, Cr. 1-2
B. Independent Study, Cr. 1-2

593. Workshop in Counseling and Guidance. (3-0) Cr. 2. SS. *Prereq: 10 hours in counselor education.* Workshops are designed to give practicing school counselors an in-depth exposure to a counseling model with concurrent opportunity for application of the model.

Courses for Graduate Students, major or minor

610. Group Counseling Practicum. (2-2) Cr. 1. F.S. *Prereq: Co Ed 580, or 581, or 582.* Supervised experience facilitating and processing counseling groups.

611. Advanced Counseling Practicum. (2-8) Cr. 4. F.S.SS. *Prereq: Co Ed 580, or 581, or 582.* An advanced practicum experience primarily designed for doctoral students. Practicum placement can be made in a variety of settings.

615. Seminar. (1-3-0) Cr. 1-2. F.S. *Prereq: 10 hours in counselor education.* Seminars are designed to meet the needs of practicing school counselors and doctoral students.

620. Supervision of Counseling Practicum. (1-6) Cr. 2. F.S. *Prereq: Minimum of 6 practicum credits.* Designed to give doctoral students the experience of supervising M.S. level practicum and leading a practicum seminar. Individual sessions with M.S. level practicum students for critique of taped counseling sessions and supervision of other practicum activities through planning, discussion, and on-site visitation.

699. Research. Cr. arr. *Prereq: 10 credits in counselor education.*

Curriculum and Instructional Media (Curr)

Lynn W. Glass, Section Leader

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

501. Principles and Practices of Educational Media. (3-0) Cr. 3. F.SS. *Prereq: Graduate classiciation.* Volker, Simonson. Organization of educational media centers in school and industrial settings. Analysis of types of hardware and software necessary to design, produce, present, and evaluate instruction with media. Application of research findings relative to media and learning. Preparation of a variety of teaching materials.

502. Producing Visual Media. Cr. 2-4. S. *Prereq: Curr 501.* Volker, Simonson. Principles of composition and design of visual instructional media as applied to still photography, film production, video tape production, or instructional graphics. Laboratory work in production of these media and analysis of research on the design, production and utilization.

503. Designing Instructional Systems. (3-0) Cr. 3. S. *Prereq: Curr 501.* Volker, Simonson. Designing, scripting, and producting instructional systems for individual and group instruction. Application of principles of programmed instruction. Analysis of past and current developments in teaching machines, computer-assisted instruction, and instructional development. Methods for evaluating instructional strategies.

504. Managing and Evaluating Media Programs. (3-0) Cr. 3. F. *Prereq: Curr 501.* Volker, Simonson. Principles and procedures for analysis of a media program in an education setting. Methods for gathering data, developing and evaluating job descriptions, and analyzing budget, personnel distribution, organization of resources, circulation and production procedures, and physical facilities. Development of in-service and public relations programs for selected media centers.

511. Teaching Assistant's Orientation Seminar. (1-1) Cr. 1. F.S. *Prereq: Graduate classification.* Volker, Simonson. Survey of basic techniques of college teaching for graduate teaching assistants who have no background in teaching. Videotaped microteaching experiences emphasizing methods of lecturing, conducting discussion, questioning and reinforcement are included, as well as simple media production and classroom testing and evaluation.

512. Strategies for Classroom Teaching. (2-3) Cr. 3. F. *Prereq: Graduate standing.* Volker. Thoretical basis and practical experience in the design, production, presentation, and evaluation of a body of knowledge in a specific content area. Behavioral objectives, production of media, microteaching, and methods for handling large group, small group, and individualized instruction.

542. The Secondary School Curriculum. (2-0) Cr. 2. F.SS. *Prereq: Teacher certification.* Dilts, Glass, McNally-Jarchow. Curricular and co-curricular programs of secondary schools; recent trends in goals, content organization, and organization for instruction; local community resources as curriculum content.

545. The Elementary School Curriculum. (2-0) Cr. 2. F.SS. *Prereq: Teacher certification.* Dilts, Glass, McNally-Jarchow. Curricular and co-curricular programs of elementary schools; recent trends in goals, content organization, and organization for instruction; local community resources as curriculum content.

590. Special Topics. Cr. 1-3. *Prereq: 9 credits of graduate work in education.*
A. Curriculum
B. Instructional Media
C. Science Education
D. Secondary Education

591. Supervised Field Experience. Cr. 1-3. *Prereq: 9 credits of graduate work in education.* Supervised on-the-job field experience in special areas.

593. Workshops. Cr. 1-3. *Prereq: 9 credits of graduate work in education.*
A. Curriculum
B. Instructional Media
C. Science Education
D. Secondary Education

594. Principles of Curriculum. (3-0) Cr. 3. F. Alt. SS., offered 1983. *Prereq: Teacher certification.* Dilts, Glass, McNally-Jarchow. Orientation to the school curriculum; definitional, theoretical and historical consideration of the curriculum; representative curriculum models and theorists.

596. Problems of Curriculum. (3-0) Cr. 3. S. Alt. SS., offered 1982. *Prereq: 6 credits of graduate work in education.* Dilts, Glass, McNally-Jarchow. An analysis of curriculum theories and principles of curriculum construction and evaluation; models in the areas of assessment, development and implementation; sociocultural factors affecting the curriculum.

Courses for Graduate Students, major or minor

615. Seminar. (0-2) Cr. 1. F.S.SS. *Prereq: Teacher certification.* Staff. Selected topics in curriculum and instructional media; an analysis of research potential; evaluation of impact upon the profession; implications for additional research.

663. Analysis of Teaching. (2-0) Cr. 2. S. *Prereq: 6 credits of graduate work in education.* Dilts, Glass, McNally-Jarchow. Critical examination of various systems for studying and evaluating teaching; descriptive studies and conceptual systems of teaching; their nature and possible uses; major research attempts to assess teaching effectiveness along with ensuing problems connected with such efforts.

699. Research. Cr. arr. *Prereq: 9 credits of graduate work in education.*
A. Curriculum
B. Instructional Media
C. Science Education
D. Secondary Education

Educational Administration (Ed Adm)

Richard Manatt, Section Leader

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

541. Principles of Educational Administration. (3-0) Cr. 3. F.SS. *Prereq: Sec Ed 426. Psych 333.* Engel, Boyles. Philosophy and purposes of education in a democratic society. Basic principles of school administration. Analysis of the nature and function of units of education at local, intermediate, and state levels; exploration of substantive elements such as school finance. Analysis of administrative skills and individual assessment of those skills.

543. The Administration of School Personnel I. (3-0) Cr. 3. Alt. F.SS. *Prereq: 9 credits in education.* Engel. Evolution of the labor management relationship. Selection and deployment of the teaching and administrative staff, personnel policies, assignment, staff development, and salary administration.

546. School Business Management. (2-0) Cr. 2. SS. *Prereq: 541.* Hart. Fiscal administration at the district and building level; functions and duties of the business manager; maintenance and operations; insurance; debt service; purchasing; district energy management; and budgeting.

548. Educational Policy Making and Interpretation. (3-0) Cr. 3. S.SS. Prereq: 541. Boyles, Engel. Functions of policy making in education; current issues in educational policy making at the local, state, and national levels; problems of implementing and interpreting policy to the community. Power structure in the community and its relationship to the educational process. Techniques and practices of public relations in the policy making and administrative functions of a school district.

549. Planning Public School Facilities. (3-0) Cr. 3. F. *Prereq: 541.* Hart. Assessment of facility needs; selection of an architect; educational specification; site selection and acquisition; schematic design and design development; contract documents and the bidding process; the construction phase; remodeling; and retrofitting for energy conservation.

557. Supervision of Instruction — Elementary and Secondary Schools. (3-0) Cr. 3. F.SS. *Prereq: 9 credits in education.* Manatt, Hohl. Purposes of educational supervision; review of contemporary methods of teaching; common techniques of supervision; evaluation of teaching and learning.

575. Fundamentals of School Law. /3-0) Cr. 3. S. *Prereq: 541, 543.* Engel. Constitutional, statutory, and judicial provisions as a basis for the legal operation of public schools. The law is examined as it affects the local school district, boards of education, administrators, teachers, and students at the elementary and secondary school levels.

576. The Administration of Elementary Schools. (3-0) Cr. 3. F.SS. *Prereq: 557.* Hohl. Patterns of elementary school organization; educational leadership through supervision, curriculum development, and in-service education. Administering pupil and auxillary services; staff and community relations.

577. The Administration of Secondary Schools. (3-0) Cr. 3. S.SS. *Prereq: 541.* Manatt, Engel. Secondary school organization, schedule making, management of pupil organizations, evaluation of pupil growth. Evaluation of the total program, staff utilization, and leadership.

590. Special Topics. Cr. 1 to 4. *Prereq: 9 credits in education.*

591. Supervised Field Experience. Cr. 1 to 6. *Prereq: 15 credits graduate work in special areas.* Supervised on-the-job field experience in special areas.

593. Workshops. Cr. 1 to 4. *Prereq: 9 credits in education.*

Courses for Graduate Students, major or minor

615. Seminar. (1-3-0) Cr. 1 to 3.

641. Administrative problems. (3-0) Cr. 3. S. *Prereq: 541, 543.* Engel. A case study approach to the resolution of problems in educational administration. Emphasis on decision-making, conflict resolution, and communication using actual situations.

643. The Administration of School Personnel II. (2-0) Cr. 2. F. *Prereq: 543.* Engel. All aspects of collective bargaining in the public sector. Selected topics such as affirmative action, legal aspects of personnel administration, evaluation of administration, and staff welfare.

644. Educational Finance. (3-0) Cr. 3. S. *Prereq: 541.* Hart. State and local tax structure in support of public education; federal programs; assessment practices; disparities in wealth among school districts; suitability of the property tax for local use; development of theoretical models of state aid formulas; practical application of the proportionate sharing formula and the foundation plan; and Iowa State aid formula.

678. Administrative Theory in Education. (3-0) Cr. 3. F. *Prereq: Master's degree, permission of instructor.* Manatt. Historical background of current thinking in administration and organization, theoretical approaches to administration; analysis of functions and processes of administration as they apply to education.

679. Advanced Administrative Theory in Education. (2-0) Cr. 2. S. *Prereq: 678.* Manatt. Critical evaluation of the major research in systems analysis, operations research, and prediction models as they apply to the management of schools and colleges; staff development techniques and theories, models and cases of organization development.

699. Research. Cr. arr. *Prereq: 9 credits in education.*

Higher Education (Hg Ed)

James Ratcliff, Section Leader

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

544. Planning Facilities for Higher Education. (2-0) Cr. 2. S. *Prereq: Graduate standing.* Includes the feasibility study, planning team and planning process, site selection, specifications, schematic design, contract documents and bidding; construction, remodeling, and energy conservation.

560. Higher Education in the United States. (3-0) Cr. 3. F.SS. *Prereq: Graduate standing.* Historical development; diversity, functions, and problems of institutions; federal programs; basic and applied research; innovative colleges; graduate education; philosophies, trends, and issues. A prerequisite for other courses in higher education.

561. Methods of College Teaching. (2-0) Cr. 2. F. *Prereq: 6 graduate credits.* Educational theory and methods relating to college teaching. Requisite abilities and responsibilities of the contemporary college teacher.

562. Curriculum and Instruction in Higher Education. (3-0) Cr. 3. S. *Prereq: 560.* Models of curriculum design; writing educational objectives; liberal, general, career, and professional education; improvement of instruction; non-traditional education.

563. College Personnel Policies and Practices. (3-0) Cr. 3. Alt. SS. *Prereq: 560.* Personnel management and problems, in-service development, salaries and fringe benefits, promotions, tenure, retirement, and recruitment practices. Faculty organizations and collective bargaining.

567. The Comprehensive Community College. (3-0) Cr. 3. Alt. S;SS. *Prereq: Graduate standing.* The community college as a unique institution: its historical development, goals and purposes, organization, programs, and specific characteristics.

574. Student Personnel Services in Higher Education. (3-0) Cr. 3. F. *Prereq: Credit or classification in 560.* An introduction to the field of student personnel work with a consideration of student activities, counseling services, financial aids, admissions, student conduct, and residential programs; includes community college programs.

575. Organization and Administration of Student Personnel Services. (2-0) Cr. 2. S. *Prereq: 574.* Organization structures, role and function of student personnel staff; policies and decision-making for student personnel services.

576. Student Development in Higher Education. (2-0) Cr. 2. S. *Prereq: 574.* The student development approach to student personnel work. Theories of student development and their applications in student personnel programs, services, and activities. Implications of developmental theories in reference to current student issues such as career planning, academic programs, and moral development will be discussed.

580. Current Topics in Community Colleges. (1-3) Cr. 1 to 3. *Prereq: Graduate classification.* Topics adjusted to specific needs of colleges. For off-campus.

590. Special Topics. Cr. 1 to 4. *Prereq: 9 credits in education.*

591. Supervised Field Experience. Cr. 1 to 4. *Prereq: 10 credits graduate work in special area.* Supervised on-the-job field experience in special areas.

593. Workshops. Cr. 1 to 5. *Prereq: 15 credits in education.*

Courses for Graduate Students, major or minor

615. Seminars in Higher Education. Cr. arr. SS (C.).
A. Student Services
B. Community Colleges
C. Current Issues

688. College Organization and Management. (3-0) Cr. 3. S. *Prereq: 560.* Administrative organization and behavior; communications; leadership; distribution of power; institutional governance. Financial administration including fund-raising, budgeting, management of sponsored research and special programs.

699. Research. Cr. arr. *Prereq: 9 credits in education.*

Historical, Philosophical, and Comparative Studies in Education (HPC Ed)

George Kizer, Section Leader

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

580. Bibliographic Research Techniques. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 9 credits in education.* Kizer. In-depth study of sources and techniques of biliographic research in education.

581. Philosophy of Education. (3-0) Cr. 3. F.SS. *Prereq: 9 credits in eduction.* Kizer. Philosophical traditions of the ancient and medieval worlds. Traditions of the modern world. Classification and analysis of contemporary American educational philosophies and theories.

583. Teaching in the Affective Domain. (3-0) Cr. 3. SS. *Prereq: 9 credits in education.* Kniker. Value theories; techniques for improving student motivation and strengthening educational relationships; analysis of affective and aesthetic education curriculum; assessment of affective objectives.

584. History of European Education. (3-0) Cr. 3. Alt. SS., offered 1983. *Prereq: 9 credits in education.* Kizer, Kniker, Smith. Educational practices and institutions in ancient Greece and Rome; medieval educational patterns; rise of university; impact of the Renaissance; national systems of education.

585. Comparative Education — European. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 9 graduate credits.* Smith. Development, principles, and uses of comparative education; comparison of the principles, practices, and institutional forms of education in selected European countries; the United Kingdom, France, the U.S.S.R., Sweden, Denmark, both Germanies, Italy, and Spain; recent movements for reform and innovations.

586. Comparative Education — Non-European. (3-0) Cr. 3. Alt. SS., offered 1982. *Prereq: 585.* Smith. Conflicting theories of the role of education in development; educational systems, practices, and issues in selected non-European countries — e.g., China, Japan, India, the Philippines; efforts at international educational assessment.

588. History of American Education. (3-0) Cr. 3. F. *Prereq: 9 credits in education.* Kizer, Kniker, Smith. Interpretations of American schooling, including revisionism; study of European roots of colonial education, development of common school, selected educational reforms of the 19th and 20th centuries. Extensive use of primary sources and biographical data.

590. Special Topics. Cr. 1 to 5. *Prereq: 9 credits in education.*
A. History of Education
B. Philosophy of Education
C. Comparative Education

591. Supervised Field Experience. Cr. 1 to 6. *Prereq: 10 graduate credits in special area.* Supervised on-the-job field experience in special areas.

593. Workshops. Cr. 1 to 5. *Prereq: 9 credits in education.*

Courses for Graduate Students, major or minor

602. Current Educational Issues. (3-0) Cr. 3. S.SS. *Prereq: 9 credits in education.* Kizer. A study in depth of selected educational issues, movements, or problems in contemporary American education.

603. Philosophical Ideas in American Education. (3-0) Cr. 3. Triennial S., offered 1984. *Prereq: 601.* Kizer. An intensive analysis and criticism of selected educational theories and philosophies. Synthesis and evaluation of their bearing on educational theory and practice.

615. Seminar. (1 to 3-0) Cr. 1 to 3. S.
A. History of Education
B. Philosophy of Education
C. Comparative Education

699. Research. Cr. arr. *Prereq: 9 credits in education.*

Research and Evaluation (Res Ev)

Anton Netusil, Section Leader

Courses Primarily for Graduate students, major or minor, open to qualified undergraduates

550. Basic Educational Research with Statistical Application. (3-0) Cr. 3. F.S.SS. *Prereq: 9 credits in education.* Introduction to educational research methodology, application of fundamental statistical concepts and basic procedures for analyzing educational data. Designed primarily for educators doing non-thesis work.

552. Beginning Educational Statistics and Research. (3-1) Cr. 3. F.SS. *Prereq: 9 credits in education, and 550 or 3 credits in mathematics.* Statistical concepts and procedures for analyzing educational data. Introduction to educational research design and descriptive statistics with educational computer applications.

553. Intermediate Educational Statistics. (3-1) Cr. 3. S.SS. *Prereq: 552.* A continuation of statistical concepts and procedures for analyzing educational data. Inferential techniques with educational computer applications.

557. Computer Applications in Education. (3-0) Cr. 3. F.SS. *Prereq: 550 or 552.* Use of computers in processing educational research data including experiences utilizing statistical packages such as SPSS and a general purpose language such as PL/1. Data coding, data representation and conversion, files, computer organization, and job control language.

560. Principles of Evaluation. (2-0) Cr. 2. F.S.SS. *Prereq: 550.* Training in the development and/or interpretation of appropriate evaluation procedures and evaluation models. Discussion of relevant topics such as norm vs. criterion referencing, domain referenced tests, competency testing, grading practices, etc.

561. Program Evaluation. (2-0) Cr. 2. F.SS. *Prereq: 550.* Techniques of conducting an evaluation of instructional programs. A variety of evaluative models will be explored and the student will apply at least one such model to an on-going program.

590. Special Topics. Cr. 1-3 each time taken. F.S.SS. *Prereq: Permission of instructor.* Guided reading and or study on special topics. Two hours normally given for creative component work.

593. Workshop. Cr. 1-3 each time taken. Offered when demand warrants. *Prereq: Permission of instructor.* Intensive, concentrated exposure to a special educational research or evaluation problem.

Courses for Graduate Students, major or minor

615. Seminar. (1-0) Cr. 1. *Prereq: 3 credits in research and evaluation, permission of instructor.* Group study and discussion on a wide variety of topics in research and evaluation.

654. Advanced Educational Research and Design. (3-0) Cr. 3. F.S.SS. *Prereq: 553.* Advanced research methodology and design of experiments. Problem selection, design, measurement, statistical analysis, and interpretation of data. Applicable for thesis or dissertation research.

699. Research. Arranged. F.S.SS. *Prereq: Permission of instructor.*

Psychology

David C. Edwards, Chair of Department

The Graduate Faculty

Members: Ahmann, Andre, Avant, Bath, Borgen, Brown, Charles, Edwards, Fritz (Emeritus), Hughes, Kahn, Karas, Lando, Layton, Lewis, Mason, Menne, Muchinsky, Peters, Phye, Reschly, Russell, Schuster, Scott, Strahan, Turnage, Warman, Wolins, Zytowski

Associate Members: Cresham, Hannum, Krulewitz

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in psychology, and minor work to students taking major work in other departments. A two-year Specialist degree program is offered in school psychology.

Students desiring a graduate major in psychology must have been graduated from an accredited college in a curriculum substantially equivalent to the undergraduate curriculum in sciences and humanities at Iowa State University. Prerequisite to admission is at least 15 credits of basic psychology, which should include a laboratory course and a measurement-statistics course.

The department also participates in the interdepartmental program of Industrial Relations (see Index).

A formal class and a supervised practicum in the teaching of psychology is required of all doctoral degree candidates and strongly recommended for master's level students whose future plans may include teaching at the college level.

Courses for Graduate Students, minor only

311L. Laboratory in Brain and Behavior. (0-4) Cr. 2. S. *Prereq: Credit or classification in 311.* Techniques of stereotaxic surgery on the rat: lesions, electrical and chemical stimulation of the brain. Behavioral analysis and histological evaluation of brain manipulations.

401. History of Psychology. (3-0) Cr. 3. S. *Prereq: 4 courses in psychology.* American psychology development including its philosophical origins, schools of thought, and modern theoretical viewpoints.

422. Counseling Theories and Techniques. (2-2) Cr. 3. F.S. *Prereq: 3 courses in psychology including 460.* Survey of major theoretical approaches in counseling and supervised practice in the specific skills and techniques employed.

425. Principles and Methods of Interviewing. (2-2) Cr. 3. F. *Prereq: 4 courses in psychology.* Selection, supervisory, case-history, counseling, and market-research interviews. Ethics of interviewers. Laboratory experience with design of questionnaires, questioning, listening, and confronting.

430. Psychology of Adolescence. (3-0) Cr. 3. F.S.SS. *Prereq: 2 courses in psychology including 230.* Developmental characteristics of the adolescent; examination of antecedents of behavior with a goal of better understanding of this age group, implications for education and guidance.

431. Psychology of Maturity and Old Age. (3-0) Cr. 3. F. *Prereq: 3 courses in psychology including 230.* Psychologically important structural and functional changes in the human from maturity to old age. Typical as well as individually unique psychomotor, cognitive, and socioemotional development and decline.

434. Principles of Behavior Modification. (3-0) Cr. 3. S. *Prereq: 313 or 333.* Basic principles and applications of behavior modification procedures with emphasis on applied settings such as classrooms, institutions, and families. Consideration of appropriate uses and ethical concerns.

436. Psychology of the Exceptional Individual. (3-0) Cr. 3. F.S.SS. *Prereq: 230, 333, 440.* Behavioral characteristics, problems, and needs of a wide variety of atypical persons, including the gifted.

440. Psychological Measurement I. (3-0) Cr. 3. F.S.SS. *Prereq: 9 credits in psychology, Stat 101.* Principles of psychological measurement, including concepts of reliability and validity; interpretation of test scores; factors influencing test performance; construction and interpretation of maximal and typical performance measures; uses and misuses of tests.

450. Industrial Psychology. (3-0) Cr. 3. F.S.SS. *Prereq: 2 courses in psychology including 101.* Content and methods of industrial psychology. Selection and placement techniques, performance appraisal, training, testing in industry, techniques of interviewing, human error, accidents, and job analysis.

451. Organizational Psychology. (3-0) Cr. 3. F.S. *Prereq: 2 courses in psychology including 101.* Content and method of organizational psychology. Emphasis on organizational theory, structure of organizations, motivation, leadership, job satisfaction, communication, problem solving, and decision making.

460. Abnormal Psychology. (3-0) Cr. 3. F.S.SS. *Prereq: 3 courses in psychology including 101.* Description of major forms of maladaptation including neuroses and psychoses. Factors in the development of behavior deviations. Research pertinent to the description, development, and maintenance of abnormal behavior.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

508. Research Methods in Applied Psychology. (3-0) Cr. 3. Alt. S. offered 1983. *Prereq: 440, Stat 402.* Research methods in natural and controlled environments; cross-sectional and longitudinal studies; observational and correlational approaches; experimental and quasiexperimental designs, single subject research procedures, time-series designs, studies of intact groups, evaluation of applied programs, person-situation interactions; metaanalytic research procedures.

511. Advanced Physiological Psychology. (3-0) Cr. 3. Alt. F. offered 1981. *Prereq: 311.* Neurophysiological correlates of behavior.

512. Advanced Perception. (3-0) Cr. 3. Alt. S. offered 1982. *Prereq: 312.* Historical and modern information processing approaches to theory and research in vision and audition.

513. Advanced Animal Learning. (3-0) Cr. 3. Alt. F. offered 1982. *Prereq: 313.* Examination of empirical and theoretical issues of classical and instrumental conditioning.

514. Advanced Human Learning, Memory, and Cognition. (3-0) Cr. 3. Alt. S. offered 1983. *Prereq: 316.* Historical and contemporary survey of human symbolic behavior, thinking, and conceptual behavior.

517. Psychopharmacology. (3-0) Cr. 3. Alt. F. offered 1981. *Prereq: 511.* Fundamentals of drug-behavior interactions with emphasis on psychoactive drugs and their use in experimental, therapeutic, and social settings.

530. Life Span Developmental Psychology. (3-0) Cr. 3. S.SS. *Prereq: 4 courses in psychology, including 230.* Psychological changes in human behavior from conception to senescence in physical, sensory, intellectual, emotional, and social development. Intensive consideration of theories, issues, and data central to a life-span model of development; major longitudinal studies emphasized.

533. Advanced Educational Psychology. (3-0) Cr. 3. F.SS. *Prereq: 3 courses in psychology, including 333.* Human learning and cognition with reference to application in educational settings. Emphasis on the effects of learner characteristics such as intellectual, personal, and social development on the learning process. Consideration given to instructional theory and models.

536. Mental Retardation. (3-0) Cr. 3. S.SS. *Prereq: 436.* Psychological characteristics of the mentally retarded including theoretical views and research on etiology, prevalence, learning, adjustment, clinical practices, and educational programs. Emphasis on current issues such as recent litigation, bias in assessment, labeling effects, and assessment of adaptive behavior.

537. Psychological Characteristics of Giftedness. (3-0) Cr. 3. Alt. S. offered 1982, Alt. SS. offered 1983. *Prereq: 3 courses in psychology, including 230.* Cognitive and affective development of giftedness throughout the life-span. Giftedness as a generic term includes the intellectually superior, the talented, and the creative. Emphasis on current theoretical views and research in cognition and problem solving, as well as social-emotional adjustment.

540. Psychological Measurement II. (3-0) Cr. 3. S. *Prereq: 440, Stat 401.* Nature of psychological measurement. Measurement and scaling theory. Theoretical and statistical definitions of reliability and validity. Introduction to multivariate methods including factor analysis.

542. Psychoeducational Assessment. (4-0) Cr. 4. F.SS. *Prereq: 440.* Theory and research concerning assessment of intelligence and achievement with emphasis on developmental patterns and diagnosis of learning problems. Critical examination of current assessment practices in clinical and educational settings.

544. Practicum in Assessment. *Prereq: 542 and permission of instructor.* Supervised practice in administering, scoring, interpreting, and reporting individual tests.
A. WISC-R and Stanford-Binet (1-2) Cr. 1. F.
B. McCarthy and ITPA (1-2) Cr. 1. S.
C. WAIS and Multiple Aptitude Tests (1-2) Cr. 1. F.

550. Advanced Industrial Psychology. (3-0) Cr. 3. F. *Prereq: 440, Stat 402.* Critical evaluation of current research, advanced methodologies, and professional problems in industrial psychology.

551. Advanced Organizational Psychology. (3-0) Cr. 3. S. *Prereq: 440, Stat 402.* Examination of organizational behavior research including motivation, job satisfaction, organizational climate, organizational effectiveness, and the environment. Attention rendered to theoretical, methodological, and applied issues.

560. Advanced Personality Psychology. (3-0) Cr. 3. F. *Prereq: 4 courses in psychology, including 360.* Analysis of theories of personality, concepts, methods, and current research issues.

561. Psychopathology and Behavior Deviations. (3-0) Cr. 3. S. *Prereq: 460.* Critical review of theoretical perspectives and current research on the development and maintenance of the major forms of maladaptation including schizophrenic, anxiety, affective, drug use, personality, psychosexual, reactive, and childhood disorders.

562. Personality Assessment. (3-0) Cr. 3. S. *Prereq: 360, 440, Stat 402.* Principles, concepts, and methods of personality assessment. Though not a practicum course, exposure is given to a variety of objective, projective, and situational tests.

580. Advanced Social Psychology I: Psychological Perspectives. (3-0) Cr. 3. F.SS. *Prereq: 4 courses in psychology, including 280.* Current theories, methods, and research in social psychology with an emphasis on individual processes such as attribution, attitude change, attraction, aggression, and helping behavior.

581. Advanced Social Psychology II: Psychological Perspectives. (3-0) Cr. 3. Alt. S. offered 1982. *Prereq: 580.* Current theories, methods, and research in social psychology with an emphasis on the individual within a social context. Focus on social interaction and interpersonal processes.

590. Special Topics. Cr. var. *Prereq: 12 credits in psychology, permission of instructor.* Guided reading on special topics or individual research projects.
A. Counseling
B. Industrial-Organizational
C. School Psychology
D. Individual Differences
E. Experimental
F. Educational
G. Physiological
I. Abnormal
J. Engineering
K. Developmental
L. Exceptional Children
M. Consumer
N. Social
O. Personality
P. Psychometrics

Courses for Graduate Students, major or minor

601. Historical and Systematic Psychology. (3-0) Cr. 3. F. *Prereq: Second year graduate classification.* Origins of psychology in philosophical, medical, and related thought. Development as an independent discipline in the nineteenth and twentieth centuries. Traditional and contemporary theoretical approaches to areas of experimental, academic, and applied psychology.

621. Psychological Counseling: Introduction to Theory, Process, and Techniques. (3-2) Cr. 4. F. *Prereq: 4 courses in psychology including 440 and 460.* Combined survey of theoretical issues and approaches with prepracticum development of counseling skills and techniques. Didactic coverage of theoretical viewpoints at an introductory level. Laboratory based development of relationship skills and interviewing techniques using modeling, role playing, and case studies.

623. Vocational Behavior. (2-0) Cr. 2. F. *Prereq: 3 courses in psychology.* Theories, research, and issues in career development and choice, relationships to job satisfaction and performance; influences of sex roles, age, sociocultural factors on career behavior.

626. Group Counseling. (2-2) Cr. 3. S. *Prereq: 621.* Survey of theoretical approaches, research, techniques, issues, and ethics in group counseling. Concurrent participation in a group counseling experience.

627. Behavior Therapy. (3-0) Cr. 3. F. *Prereq: 513.* Research and theory underlying application of learning principles to techniques of behavior change. Introduction to methods of behavior analysis and techniques of behavior therapy.

628. Advanced Counseling Theory. (2-0) Cr. 2. S. *Prereq: Practicum in counseling psychology.* In-depth coverage of major theoretical positions, including comparative analysis. Coverage and evaluation of research on counseling interventions.

633. Teaching of Psychology. (1-0) Cr. 1. F. *Prereq: Enrollment in degree program in psychology, completion of at least 1 year of graduate study, permission of instructor.* Orientation to teaching of psychology at college level: academic issues and problems, instructional and evaluative techniques.

642. Advanced Psychological Assessment. (2-2) Cr. 3. Alt. S. offered 1983. *Prereq: 542 or 562.* Analysis of modes of and problems in assessment including theory and research on test bias. Consideration of alternatives to standardized tests such as behavioral methods of assessment and use of socio-cultural information in interpretation of test scores.

652. Human Decision Theory. (3-0) Cr. 3. Alt. S. offered 1982. *Prereq: 540, Stat 401.* Critical analysis of the human judgment process as represented by normative and descriptive statistical models of decision making. Emphasis on issues in human decision making research as policy capturing, boot-strapping, and non-linear inference strategies.

691. Practicum in Psychology. Cr. var. *Prereq: Permission of instructor.* Supervised practice and experience in the following fields of specialization in applied psychology.
A. Counseling
B. Industrial-Organizational
C. School Psychology
D. Individual Differences
T. Teaching. *Prereq: 633.* S-F grading

692. Seminar in Psychology. (1-0 to 3-0) Cr. 1 to 3 each time taken. Offered when demand warrants.
A. Counseling
B. Industrial-Organizational
C. School Psychology
D. Individual Differences
E. Experimental
F. Educational
G. Physiological
I. Abnormal
J. Engineering
K. Developmental
L. Behavioral Consultation
M. Professional Issues and Ethics
N. Social
O. Personality
P. Psychometrics

699. Research.

Religious Studies

For description of courses, see *Philosophy*.

Secondary Education

See *Professional Studies in Education* for description of courses.

Sociology and Anthropology

Gerald E. Klonglan, Chair of Department

The Graduate Faculty

Members: Bohlen, Bower, Bultena, Chang, Cohen, Dean, Goudy, Gradwohl, Keith, Klonglan, Mulford, E. A. Powers, R. C. Powers, Richard, Schafer, Schuster, Simons, Tait, Warren, Whiteford, Woodman

Associate Members: Aigner, Bruton, Harrod, Hoiberg, Hoyt, Hraba, Huang, Johnson, Korsching, Lee, Miller, Nowak, Rombough, Ryan, Wilcox, Winkelpleck

Sociology

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in sociology and rural sociology and minor work for students majoring in other departments. For M.S. and Ph.D. departmental requirements, see "Program of Graduate Study for Degrees in Sociology and Rural Sociology," available from the department office. Some of the fields of possible concentration are community studies and development, complex organizations, crime and deviance, environmental sociology, family, gerontology, methodology, population/ecology, rural sociology, social change and development, social organization, social psychology, and sociological theory. Within the sociology major students may specialize in anthropology at the master's level. The sociology department does not offer a nonthesis master's program.

Although the department stipulates no language requirement for either the degree Master of Science or the degree Doctor of Philosophy, specifying competence in one or more languages may be desirable in some instances.

The department participates in the interdepartmental programs of Gerontology, Industrial Relations, Technology and Social Change, Transportation Planning, and Water Resources (See Index).

Courses for Graduate Students, minor only

400. History of Sociological Thought. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 130 or 134.* Surveys the source and content of sociological thinking from ancient civilizations to roughly 1900.

401. Contemporary Sociological Theories. (3-0) Cr. 3. F.S. *Prereq: 130 or 134.* Contemporary sociological theories and applied uses for researching, understanding, and analyzing the social world.

405.Sociology of Language (Sociolinguistics). (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 130 or 134; Anthr 221 or Engl 219.* Analysis of language structure and linguistic behavior in various social contexts; language and technological change; language planning; linguistic behavior relative to social stratification, ethnic and racial groups, and reference groups; language in socialization and assimilation; language problems in social change.

410. Urban Sociology. (3-0) Cr. 3 or (3-1) Cr. 4. S. *Prereq: 130 or 134.* Growth, structure, and functions of the city; urban-social relations. Optional fourth credit entails guided research or other complementary study.

***411. Societal Change and Development.** (3-0) Cr. 3. F. *Prereq: 130 or 134.* Contemporary changes in rural and urban society with analysis of social institutions, social organizations, and social values. Theories of social change. Adequacy of existing social structures to meet needs of people. Alternative development structures and strategies to meet changing needs.

***415. Adoption and Diffusion of Innovations.** (3-0) Cr. 3. S. *Prereq: 130 or 134.* Processes of adoption and diffusion of innovations. Factors related to differential

rates of adoption of new technology, such as sources of information, attitudes, values, knowledge, and personal and social characteristics.

***420. Analysis of Complex Organizations.** (3-0) Cr. 3. F.SS. *Prereq: 130 or 134.* Organizations as bureaucratic social systems. Emphasis on creation of organizations and agencies and their internal operations; linkages among agencies and to the general public.

425. Mass Movements in Modern Societies. (3-0) Cr. 3. F. *Prereq: 130 or 134.* Comparative analysis of individual, cultural, and social factors involved in collective behavior (crowds, mobs, riots), natural disasters, and social movements. Theoretical approaches such as symbolic interactionism, field, and conflict utilized to interpret perceptions, values, norms, goals, organization, and social effects of the above.

440. Juvenile Delinquency and the Justice System. (3-0) Cr. 3. F. *Prereq: 130 or 134.* Analysis of meanings of juvenile delinquency. Examination of the juvenile justice system. Critcial issues in juvenile justice and ways to approach the issues and possible solutions. Fee.

461. Sociology of the Life Cycle. (3-0) Cr. 3. F. *Prereq: 130 or 134.* Theoretical and empirical perspectives on individuals facing developmental tasks, age related norms, values, and subcultures. Decisions and issues faced by individuals as they progress through stages of the life cycle.

462. Social Work Skills and Strategies for Intervention in Small Systems. (4-0) Cr. 4. F. *Prereq: Admission to social work program.* General skills for social work: problem assessment, data collection; strategies for intervention with individuals, families, and small groups as target systems.

463. Social Work Skills and Strategies for Intervention with Large Systems. (4-0) Cr. 4. F. *Prereq: 261, credit or classification in 461, 462.* Issues and skills for planned change in planning and allocation policy arenas regarding social provisions and social services; human service organizations and policy units from the local to the national level examined with respect to issue identification, policy objectives, organizational structure and processes, values, and evaluation.

***464. Community Action.** (3-0) Cr. 3. F.S. *Prereq: 130 or 134.* Community analysis of mobilization and organization of human and social system resources for social action programs.

473. Sociology of Youth. (3-0) Cr. 3. S.SS. *Prereq: 130 or 134.* Sociological analysis of development of youth subcultures in society; socialization in complex society and social implications of youth transition into adult culture.

476. The Aged in American Society. (3-0) Cr. 3. S. *Prereq: 130 or 134.* A survey of sociological problems of the aging and the social implications of a sizable aged population.

485. Sociology of the Family. (3-0) Cr. 3. F.S.SS. *Prereq: 130 or 134.* The family as a primary group in mass societies.

Courses Primarily for Graduate students, major or minor, open to qualified undergraduates

511. Intermediate Research Methods. (2-2) Cr. 3. F. *Prereq: 302.* Research methods in sociology including both qualitative and quantitative approaches: problem selection, hypothesis formulation, designs, sampling, measurement, data collection and analysis, proposal writing.

516. Qualitative Methodology. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 6 credits in sociology.* The art of qualitative data gathering and analytic techniques. Observation, participant-observation, case studies, in-depth interviews, life histories, life sculpting, content analysis. Videotape practice.

517. Sociological Evaluation Research Methods. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 6 credits in sociology.* Examination of methodological models and techniques appropriate to the sociological evaluation of planned social action programs implemented by legislation and/or human service organizations.

520. Social Psychology: A Sociological Perspective. (3-0) Cr. 3. F. *Prereq: 305 or Psych 280.* Examination of cognitive, symbolic interaction, exchange, role-reference group, and dramaturgical approaches. Assessment of contemporary issues in social psychology.

521. Small Groups. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 305 or Psych 280.* Examination of alternative theoretical models and methods of studying small groups.

522. Attitude and Attitude Change. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 305 or Psych 280.* Analysis of theories of attitude and attitude change; current controversies between the theories examined, as well as supporting research.

527. Socialization. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 6 credits in sociology.* Research and theory on human socialization throughout the life cycle. Socialization studied as an organizational process; impacts of social change on socialization content and processes.

529. Minority Groups. (3-0) Cr. 3. Alt. SS., offered 1982. *Prereq: 6 credits in sociology.* Perspectives in intergroup relations; ethnicity in the modern world; examination of theory and research on intergroup relations; implications of research for policy.

530. Social Organization. (3-0) Cr. 3. S. *Prereq: 6 credits in sociology.* Methodological and analytical issues associated with the study of group structure; contemporary theories of social organization; data analysis issues involving social organization.

***532. Organizations and Their Environments.** (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 6 credits in sociology.* Comparative analysis of complex organizations. Complex organizations as semi-open systems. Interorganizational relations and organizational effectiveness.

***533. Models of Community.** (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 6 credits in sociology.* Emphasis on different models or frames of reference used in community analysis. Theoretical and methodological tools, current views of community problems, and explanation of social and cultural change presented for each model.

***538. Sociology of Leisure.** (3-0) Cr. 3. Alt. SS., offered 1982. *Prereq: 6 credits in sociology.* Theory and research on the patterns, correlates, and functions of leisure behavior. Consideration of conceptual and methodological problems in studying leisure.

***540. Contemporary Theories of Social Change.** (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 6 credits in sociology.* Contemporary theories of social change, modernization and development are critically examined; theoretical and methodological issues identified; supporting research explored; and, the applicability of theoretical models, concepts, and strategies to current national and international needs evaluated.

546. Applied Sociolinguistics: Linguistic Problems of Developing Nations. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 6 credits in sociology.* Analysis of sociolinguistic problems and solutions in multilingual developing nations; language planning and adoption and diffusion of language policies; language problems in technological change.

***548. Sociology of Environmental Resources.** (3-0) Cr. 3. Alt. SS., offered 1983. *Prereq: 6 credits in sociology.* Theory and research on contemporary environmental topics and issues, including social impact assessment, equity considerations in resource use, environmental quality movement, environmental values, energy conservation, land-use conflict, and natural resources management.

550. Principles of Population. (3-0) Cr. 3. Alt. SS, offered 1982. *Prereq: 6 credits in sociology.* Examination and critique of demographic theories; methods and techniques of measuring demographic phenomena; historical and current population trends; survey of current research on population.

555. Human Ecology. (3-0) Cr. 3. Alt. SS., offered 1983. *Prereq: 6 credits in sociology.* Historical and theoretical development of human ecology. Analysis of human settlements, social organization and the environment, and ecological methods.

562. Social Deviance. (3-0) Cr. 3. Alt. SS., offered 1983. *Prereq: 6 credits in sociology.* Examination of theory and research relevant to the meaning, identification, and causes of deviant behavior.

564. Criminal and Juvenile Justice: Process and Institutions. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 6 credits in sociology.* Examination of the criminal and juvenile justice systems. The dynamics of contemporary police, judicial, correctional institutions, and community-based rehabilitation programs are evaluated in the context of key historical developments, theory, and research.

566. Political Sociology. (3-0) Cr. 3. Alt. SS., offered 1982. *Prereq: 6 credits in sociology.* Analysis of power, mass society, and elite formation; ideology and its uses.

575. The Family in Changing Societies. (3-0) Cr. 3. Alt. SS., offered 1983. *Prereq: 6 credits in sociology.* Analysis of the relationships of the family and other institutions, emphasis on rural-urban differences; the family in modern and changing societies.

576. Sociological Perspectives on Aging. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 6 credits in sociology.* Theoretical perspectives on the aging process; social and social-psychological changes accompanying aging; age considerations in American society.

590. Special Topics. Cr. 1 to 3 each time taken. *Prereq: 6 credits in sociology; senior or graduate classification.*
*A. Rural Sociology
B. General Sociology

591. Orientation to Sociology. (1-0) Cr. R. F. Introduction to the department, current graduate student policies at department and university levels, departmental administrative procedures. Required of graduate students. Offered on a satisfactory-fail basis only.

599. Research for Master's Thesis.
*A. Rural Sociology
B. General Sociology

Courses for Graduate Students, major or minor

600. Intermediate Sociological Inquiry and Theory. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 511.* Units of sociological analysis. Taxonomies in sociology; concepts, subconcepts, levels of concepts. Elements of systematic sociological theory; propositions, explanation, prediction, cause. Use of sociological theory in research.

605. Historical Sociological Theory. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 6 graduate credits in sociology.* Evolution of sociological thinking focusing on the era from the Enlightenment to 1900. Positivism, conflict and functionalist traditions, organicism, and sociology of knowledge perspectives.

607. Contemporary Sociological Theory. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 6 graduate credits in sociology.* Survey of theoretical developments since 1900, including the rise of structural-functionalism, symbolic interactionism, conflict theories, phenomenology, exchange theory and others.

611. Sociological Measurement. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 511.* Principles of measurement for major sociological variables. Foundations of measurement; types of sociological variables; construction of sociological measures, indices and scales; methods of data collection.

***613. Advanced Theory Construction and Causal Modeling.** (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 511, 600.* Contemporary theory construction in sociology, models in sociology, formal strategies to theory construction, notion of causality in sociology, contemporary approaches to causal analysis.

***642. Sociology of Adoption and Diffusion.** (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 6 graduate credits in sociology.* Sociological and social psychological theories related to adoption and diffusion of new ideas. Analysis of adoption and diffusion models; methods of field research. Factors related to rates and intensity of adoption and diffusion. Adopters' characteristics related to rates of adoption.

***645. Applied Sociology.** (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 6 graduate credits in sociology.* Orientation of applied sociology; roles and institutional settings of applied sociologists; application of sociological theory and research to social problems. Emphasis is given to both rural and urban settings.

698. Seminars in Sociology. (3-0) Cr. 3 each.
A. Social Theory and Research
B. Methodology
*C. Applied Sociology

699. Dissertation Research.
*A. Rural Sociology
B. General Sociology

***Administered through the College of Agriculture. Courses not marked by an asterisk are administered through the College of Sciences and Humanities. †Credit from only one of 130 and 134 may be applied toward graduation.**

Anthropology

The Department of Sociology and Anthropology offers the degree Master of Arts in Anthropology. Graduate courses are given in the areas of biological anthropology, archaeology, sociocultural anthropology, linguistic anthropology, history and theory, and methodology. Competence in one foreign language and in statistics is to be demonstrated. A thesis, generally based on original fieldwork, is required.

420. Archaeology of North America. (Am In 420) (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 220, or 320, or 322.* Prehistory and early history of North America as reconstructed from archaeological evidence; peopling of the New World; culture-historical sequences of major culture areas north of the Rio Grande; linkages of archaeological traditions which selected ethnohistorically known Native American groups.

426. Archaeology of Europe and the Near East. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 220 or 320.* Ancient Europe from Paleolithic cultures to early literate societies as reconstructed from archaeological evidence: prehistoric background of Near Eastern and Mediterranean civilizations and their relationships to European peoples up to the time of the Roman empire.

428. Archaeological Laboratory Methods and Techniques. Cr. 3. Alt. S., 1983. *Prereq: 220, permission of instructor.* Individual and/or group projects including laboratory processing and analysis of archaeological materials, experiments in technologies such as manufacture of stone tools or ceramics, writing a preliminary site report, design and preparation of a museum display.

429. Archaeological Field School. Cr. 8 to 10. SS. 8 to 10 weeks. *Prereq: 220, permission of instructor.* Summer field school for training in archaeological reconnaissance and excavation techniques; documentation and interpretation of archaeological evidence.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Language and Culture. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 221.* Structure and design of language; functional relationships between language, cognition, and culture; linguistic change; social and linguistic aspects of verbal behavior; language, world view, and cognitive style.

503. Primate Evolution. (3-2) Cr. 4. Alt. S., offered 1983. *Prereq: 219 or Zool 206L.* Comparative studies of the morphology and behavior of primates in neontological and paleontological perspective. Laboratory analysis of locomotor adaptations and variability in habitus and heritage; limb bones, muscles and fossil casts. Fee.

505. Urban Anthropology. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 6 credits in anthropology.* Origins of urbanism; patterns of urban growth; migration to cities; effects of urbanization processes on the countryside.

510. Contemporary Sociocultural Anthropology. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 6 credits in anthropology.* Survey of current developments in topical approaches to sociocultural anthropology. Examination and assessment of controversies; new research directions; quantitative and qualitative methods; formulation of research paradigms for advanced studies.

520. Cultural Continuity and Change in the Prairie-Plains. (Am In 520) (3-0) Alt. F., offered 1981. *Prereq: 322, or 420, or 429.* Ecological adaptations, sociocultural changes, and continuities of traditions among Prairie and Plains Indian groups through time; impacts of Euro-American society and technology on Indians of the Great Plains; perspectives from ecology, archaeology, ethnology, history, and contemporary literary sources.

522. Seminar on American Indians. (Am In 522) (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 322 or 332.* Research and discussion of selected topics on contemporary and/or traditional Native American cultures.

529. Advanced Archaeological Methods. Cr. 1 to 5. F.S.SS. May be taken for 8 to 10 credits in summer field school. *Prereq: 429, permission of instructor.* Archaeological field techniques and laboratory methods. Reconstruction of sociocultural activities from archaeolgical evidence.

530. Field Problems in the Ethnology of Contemporary Societies. Cr. 3 to 5. Alt. F., offered 1981. May be taken for 8 to 10 credits in summer field school. *Prereq: 6 credits anthropology, permission of instructor.* Field training experience in ethnography. Problems emphasizing field studies in the contemporary societies of the world.

533. Medical Anthropology. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 6 credits in anthropology.* Study of human health in cultural and environmental context; comparison of health and disease patterns of western and non-western populations; use of epidemiological models in understanding illness and disease etiologies cross-culturally; interrelationship between diet and culture.

555. Seminar in Archaeology. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 320, or 334, or 420, or 426, or 429.* Critical review and examination of traditional and contemporary methods and theories involved in the study of human behavior in the past.

560. Topical Studies in Anthropology. (3-0) Cr. 3 each time taken. *Prereq: 6 credits in anthropology, permission of instructor.* Graduate study in conjunction with a 300- or 400-level course in the topics listed below. May not be taken in conjunction with a 300- or 400-level course in which the student has previously earned credit.

A. Religion
B. Kinship
C. Psychological
D. Culture Change
E. Ekistics
F. Archaeological
G. Economic
H. Visual Arts

561. Regional Studies in Anthropology. (3-0) Cr. 3 each time taken. *Prereq: 6 credits in anthropology, permission of instructor.* Graduate study in conjunction with a 300- or 400-level course in the areas listed below. May not be taken in conjunction with a 300- or 400-level course in which the student has previously earned credit.

A. North American Indian Ethnology
B. North American Archaeology
C. Latin American Ethnology
D. African Ethnology
E. African Archaeology
F. European Ethnology
G. Near Eastern Ethnology
H. European and Near Eastern Archaeology
I. Asian Ethnology
J. Oceanian Ethnology

590. Special Topics. Cr. 1 to 5. *Prereq: 10 credits in anthropology; senior or graduate classification.*

598. Advanced Topics in Anthropology. (3-0) Cr. 3 each.

599. Research.

Speech

Linda J. Busby, Acting Chair of Department

The Graduate Faculty

Members: Busky, Nelson, Underhill

Associate Members: Connolly, Dearin, Drexler, Myers, Weaver, Wilson

The department offers courses for a graduate minor in speech as well as supporting work for other fields. Speech also participates in the interdepartmental program leading to a master's degree in General Graduate Studies.

Courses for Graduate Students, minor only

Communication Disorders (Sp)

371. Language Development. (3-0) Cr. 3. F. *Prereq: 275.* Developmental process of language and speech acquisition in children; pragmatics of children's communication.

376. Articulation Disorders. (3-0) Cr. 3. F. *Prereq: 270, 271, 275.* Nature, etiology, assessment and management of disorders of speech sound production.

385. Audiology. (3-0) Cr. 3. S. *Prereq: 270, 275.* Nature, etiology, and assessment of hearing disorders.

475. Neurogenic Communicative Disorders. (3-0) Cr. 3. S. *Prereq: 270, 275.* Nature, etiology, assessment, and management of neurogenic communicative disorders.

477. Fluency Disorders. (3-0) Cr. 3. F. *Prereq: 275.* Nature, etiology, assessment and management of fluency disorders.

479. Practicum in Communication Disorders. Cr. 1 to 2 each time taken, maximum of 4. F.S.SS. *Prereq: 379; 376 or 477 or 480; grade point average of 3.0 in communication disorders courses; permission of instructor.*

480. Language Disorders of Children. (3-0) Cr. 3. F.S.SS. *Prereq: 371.* Nature, etiology, assessment and management of disorders of language in children and adolescents.

Interpersonal and Rhetorical Communication (Sp)

305. Semantics. (3-0) Cr. 3. F.S.SS. *Prereq: Engl 105.* Nature of symbolic processes; determination of meanings; major approaches to linguistic study; impact of verbal habits in human affairs; relationships between language and thought in personal or social problems; accuracy in use of verbal symbols.

327. Persuasion. (3-0) Cr. 3. F.S.SS. *Prereq: 211 or 212.* Examination of behavioral research in persuasion; scientific methods of evaluating persuasive communication; emphasis on application of experimental research: audience analysis, attention, perception, suggestion; logical, emotional and ethical proofs.

412. Speech Criticism. (3-0) Cr. 3. F. *Prereq: 211 or 212, and 6 credits of Speech.* Development of rhetorical theory and practice from Corax to modern times. Application of principles of criticism to current public speaking practices.

Telecommunicative Arts (Sp)

433. Advanced Television Production/Direction. (1-4) Cr. 3. F. *Prereq: 333.* Procedures for planning, producing, and directing television programs. Emphasis on translation of facts, ideas, emotions and attitudes into meaningful images.

434. Film Production and Structure. (3-0) Cr. 3. S. *Prereq: Jl MC 319.* Survey of film production with emphasis on relationship between writing and total production process. Exercises designed to develop skills in conceptualization, scripting, and continuity, and to relate filmic form and content to styles of direction, cinematography, lighting, sound, and editing.

435. Intermediate Film Production. (2-2) Cr. 3. F. *Prereq: 434.* Practical experience in technique of film production. Preproduction planning, budgeting, production management, location and sync-sound filming, sound recording, transfers, mixing, and editing. Emphasis on professional production procedures.

Theatre (Sp)

465. History of Theatre I. (3-0) Cr. 3. F. *Prereq: Hist 201.* Theatrical art from ancient times to 1800.

466. History of Theatre II. (3-0) Cr. 3. S. *Prereq: 465.* Theatrical art from 1800 to present.

Courses Primarily for Graduate Students, Major or Minor, open to qualified undergraduates.*

504. Seminar. Cr. 1 to 3 each time taken. F.S.SS. *Prereq: 9 credits in speech.* Topics may be included in the following areas:

A. Communication Disorders
B. Interpersonal and Rhetorical Communication
C. Telecommunicative Arts
   1. Mass Media and Society
   2. Women, Minorities, and Mass Media
   3. Broadcast Survey Research
   4. Film in Third World Culture
   5. Women and Cinema
D. Theatre
E. Speech Education

510. Classical Rhetoric. (3-0) Cr. 3. S. *Prereq: 12 hours of speech.* Greek and Roman tradition in rhetorical theory, practice, criticism, and pedagogy.

532. Radio Research and Programming. (2-2) Cr. 3 each time taken, maximum of 6 credits. S. *Prereq: 330 or graduate classification.* Research methods, program formats, directing, and management principles as related to radio.

533. Broadcast Program Production. (2-3) Cr. 1 to 3 each time taken, maximum of 6 credits. S. *Prereq: 433.* Topics selected by students for half-hour programs. Research, planning, production, and direction in WOI studios.

536. Film Practicum. (1-6) Cr. 3 each. S. *Prereq: 435.* Application of production techniques in a complete 16 mm sound film project of professional quality. Students work together as crew members as the project evolves from conception to completion including research, scripting, filming, sound recording, animation, editing, and the post production functions.

551. Advanced Acting. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 351.* In-depth study and practice of period pieces and acting styles.

555. Directing Practicum. (1-2) Cr. 2. S. *Prereq: 455.* Practical experience in directing the stage play.

556. Directing the Educational Theatre Program. (3-0) Cr. 3. SS. *Prereq: Graduate classification, permission of instructor.* Problems in directing educational theatre, play selection and new dramatic literature, theatre management, directing college and high school drama programs, conducting high school drama contests and festivals.

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*Open to junior and senior-level students with a grade point average above 3.0.

563. Theory and Criticism of Dramatic Production. (3-0) Cr. 3. SS. *Prereq: 6 credits in theatre or dramatic literature.* Examination of critical theories of play production from Aristotle to modern critics.

590. Special Topics. Cr. 1 to 4 each time taken, maximum of 12 credits. *Prereq: Permission of department chairman.*
A. Communication Disorders
B. Interpersonal and Rhetorical Communication
C. Telecommunicative Arts
D. Theatre
E. Speech Education

599. Research.

Statistics

Herbert A. David, Head of Department

The Graduate Faculty

Members: Athreya, Bancroft (Emeritus), C. P. Cox, D. F. Cox, H. T. David, Fuller, Ghosh, Han, Harville, Hinz, Isaacson, Kempthorne, Kennedy, Meeden, Meeker, Pollak, Sposito, Strahan, Wolins

Associate Members: Bailey, Booth, Goebel, Groeneveld, Hickman, Hotchkiss, Koehler, Marasinghe, Shelley, Stephenson, Sukhatme, Van Nostrand

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in statistics, and minor work for students majoring in other departments. Within the statistics major the student may specialize in experimental design, probability, statistical methods, statistical theory, statistical computing, survey sampling, or applied statistics (e.g., biometrics, econometrics, psychometrics, sociometrics, etc). A specialization in operations research is co-offered with the Department of Industrial Engineering. The doctor of philosophy degree is offered as a co-major with other departments. Such departments have included Agricultural Engineering, Agronomy, Animal Science, Economics, Forestry, Genetics, Industrial Engineering, Psychology, and Mathematics.

Prerequisite to major graduate work is the completion of an undergraduate curriculum essentially equivalent to the curriculum in sciences and humanities at this institution including at least a year of calculus.

The degree Master of Science may be earned on either a thesis or nonthesis basis. The nonthesis option requires the completion of at least 34 credits of acceptable graduate work and satisfactory performance on a written examination.

The department encourages students to prepare themselves in foreign languages and in computer language, but specific requirements for the degrees master of science and doctor of philosophy are at the discretion of the student's advisory committee.

Courses for Graduate Students, minor only

401. Statistical Methods for Research Workers. (3-2) Cr. 4. F.S.SS. *Prereq: 101 or graduate classification.* Statistical concepts and models; estimation; hypothesis tests with continuous and discrete data; simple and multiple linear regression and correlation; introduction to analysis of variance.

402. Statistical Design and the Analysis of Experiments. (2-2) Cr. 3. S.SS. *Prereq: 401.* The role of statistics in research and the principles of experimental design. Experimental units, randomization, replication, blocking, subdividing and repeatedly measuring experimental units; factorial treatment designs and confounding; extensions of the analysis of variance to cover general crossed and nested classifications and models that include both classificatory and continuous factors.

403. Nonparametric Statistical Methods. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 228 or 401.* Groeneveld. Analysis of data when dependent variable has ordinal or nominal properties; statistical inference for ranked data; rank correlation; efficiency of nonparametric procedures and robustness of comparable parametric procedures.

404. Statistics for the Social Sciences. (2-2) Cr. 3. F. *Prereq: 401.* Application of statistical methods to data in the social sciences; generalized linear regression models; covariance; miscellaneous estimation problems; path analysis; constructing composite measures; procedures with measurement error present.

405. Applied Econometric Statistics. (2-2) Cr. 3. S. *Prereq: 401.* Hickman. Linear regression models containing classification and continuous variables; analysis of variance; dummy variables; grafted polynomials; generalized least squares; autocorrelation; lagged variables; introduction to simultaneous equations, two-stage least squares.

407. Methods of Multivariate Analysis. (2-0) Cr. 2. F. *Prereq: 402, knowledge of matrix algebra.* Techniques of analyzing multivariate data including Hotelling's T^2, multivariate analysis of variance, principal components, cluster analysis.

421. Survey Sampling Techniques. (2-2) Cr. 3. S. *Prereq: 228 or 401.* Methods of designing and analyzing survey investigations; simple random, stratified, multistage, and multiphase sampling designs; methods of estimation including ratio and regression; construction and use of sample frames; organization of field work; data processing.

431. Statistical Methods in Quality Control. (2-0) Cr. 2. F. *Prereq: 228 or 231 or 401.* Single sampling plans for mean and attributes; sequential sampling; continuous sampling; control charts and process control.

432. Applied Probability Models. (3-0) Cr. 3. F. *Prereq: 231 or 341.* Probabilistic models in engineering and the physical sciences; probability; Markov chains; Poisson and renewal processes; applications to queueing, scheduling, control, reliability, and other quantitative problems.

436. Genetic Statistics for Research Workers. (3-0) Cr. 3. F. *Prereq: 402.* Bailey. Statistical concepts in quantitative genetics. Derivation, definition and estimation of genetic parameters. Applications of statistical models to the design, analysis and interpretation of quantitative genetic experiments. Genetic and statistical implications of common selection procedures.

447. Statistical Theory for Research Workers. (3-0) Cr. 3. S.SS. *Prereq: 446 or Math 166.* Primarily for graduate students not majoring in statistics. Emphasis on aspects of the theory underlying statistical methods. Probability, population distribution functions and their properties, sampling distributions, orthogonal linear functions, estimation, tests of hypotheses, regression, introduction to analysis of variance.

451. Applied Time Series. (3-0) Cr. 3. S. *Prereq: 228 or 401.* Meeker. Methods for analyzing data collected over time; review of multiple regression analysis. Elementary forecasting methods: moving averages and exponential smoothing; adaptive methods. Decomposition and seasonal adjustment of time series data. Autoregressive-moving average (Box-Jenkins) models: identification, estimation, diagnostic checking, and forecasting.

480. Statistical Applications of Digital Computers. (3-0) Cr. 3. F. *Prereq: 101, 104 or classification in 401; Com S 172 or knowledge of FORTRAN.* Techniques of programming for statistical applications. Programming in algorithmic languages. Efficiency and numerical accuracy in algorithms. Introduction to Monte Carlo methods and statistical techniques in simulation. Principles of numerical analysis.

481. Computer Processing of Statistical Data. (3-0) Cr. 3. S. *Prereq: 401; Com S 172 or knowledge of FORTRAN.* The computer as a tool for statistical data analysis. Data structuring, file manipulation, and use of various data storage media. Algorithms, structure, and content of statistical packages. Advanced techniques in use of statistical software systems.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Statistical Methods. (3-2) Cr. 4. F. *Prereq: 101 and credit or classification in 542 and 579.* Hinz, Koehler. Introduction to methods and analyzing data from experiments and surveys. Methods of analysis of variance including cross classifications; correlation; multiple regression; introduction to multiple comparisons; covariance; contingency table analysis. Current computer software utilized in data analyses.

501. Multivariate Statistical Methods. (3-0) Cr. 3. S. *Prereq: 500 or 402; 447 or 542; knowledge of matrix algebra.* Koehler. Elementary theory and techniques of analyzing multivariate data including Hotelling's T^2, multivariate analysis of variance, principal components, linear discrimination, canonical correlation. Analysis of categorical data including log-linear and logistic models.

511. Theory and Application of Linear Models. (3-0) Cr. 3. S. *Prereq: 500 or 402 or 404 or 405; 542 or 447; a course in matrix algebra.* Harville, Kempthorne. Standard functional and classificatory models, matrix preliminaries, identifiability and estimability, intermediate theory of least squares and of best linear unbiased estimation, analysis of variance and covariance, reparameterization, multiple comparisons, variance components, elementary randomization models and analysis.

512. Design of Experiments. (3-0) Cr. 3. F. *Prereq: 511.* Kempthorne, Harville. Basic ideas of experimental design with applications; completely randomized design, randomized block design, randomization theory, estimation and tests, analysis of covariance with these designs; Latin square design, elementary combinatorics with Galois fields, randomization analysis; factorial experiments, confounding, fractional replication; split-plot designs; incomplete block designs in general, balanced and partially balanced designs, associated mixed linear models, intra- and inter- block information; strategies in factor screening; determination of optimum factor combinations; basic ideas of optimal design.

521. Theory of Sample Surveys I. (3-0) Cr. 3. S. *Prereq: 401; 447 or 542.* Goebel. Basic concepts and theory of designing sample surveys for finite populations; estimation of means, totals, proportions, variances, and covariances; frequently used designs such as simple random, stratified, systematic, cluster, and multistage sampling; ratio and regression methods of estimation.

522. Theory of Sample Surveys II. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 521.* Goebel. Further topics in design and estimation; unequal probability sampling, optimal stratification, multipurpose surveys, ratio and regression methods involving several auxiliary variables, double sampling, sampling over time, nonsampling errors and variance estimation for complex designs.

531. Sequential Product and Process Control (I E 531). (3-0) Cr. 3., Alt. S., offered 1983. *Prereq: 343 or 447.* Sampling, sequential analysis, estimation, Bayesian sampling, continuous sampling, and process control.

533. Reliability (I E 533). (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 231 or 342 or 432 or 447.* H. T. David, Ghosh. Probabilistic modeling and inference in reliability; replacement, maintenance and inspection policies; applications.

534. Ecological Statistics. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 447 or 542.* Pollak. Models of population growth; growth of populations with two competing species; parasite-host and predator-prey relationships; elementary population genetics; selection, mutation, and migration; spatial patterns in populations with one or more species; diversity; information theory.

535. Biological Statistics. (2-0) Cr. 2. Alt. SS., offered 1983. *Prereq: 401 or 500.* C. P. Cox. Direct and indirect biological assay; dose response curves; estimations from standard curves; parallel line and slope ratio assay; experimental designs for bioassay; multiple assays; quantal response assay analyses; radioimmunoassay; other biostatistical procedures according to student interests.

536, 537. Genetic Statistics. (Gen 536, 537) (2-0) Cr. 2 each. 536: Alt. F., offered 1981; 537: Alt S., offered 1982. *Prereq: 402, 448; Gen 320 or 330 or 460, permission of instructor.* Pollak. Probability applied to genetic systems; random mating; selection and mutation; theory of inbreeding; some effects of finite population size; models for quantitative inheritance; partition of genotypic variance; covariances among relatives with random mating and selfing; experimental designs for evaluating parameters; phenotypic selection for quantitative traits.

538. Econometric Statistics. (Econ 538). (3-0) Cr. 3. F. *Prereq: 447.* Fuller. Generalized linear regression. Dummy variables, prediction. Measurement error models. Simultaneous equation systems. Autoregressive and moving average time series. Prediction. Regression equations with time series errors.

539. Game Theory. (Econ 539, I E 539) (3-0) Cr. 3. F. *Prereq: 231 or 342 or 432 or 447.* H. T. David. Zero-sum two person games; games of timing; relation to mathematical programming; non-cooperative and cooperative n-person games.

540. Operations Research Methods and Economic Analysis. (3-0) Cr. 3. S. *Prereq: 539 or I E 511 or Econ 537.* Sposito. Methods and applications of selected techniques in nonlinear programming, including linear, convex and quadratic programming. Applications in economics and operations research.

542, 543. Theory of Probability and Statistics. (3-0) Cr. 3 each, Yr. *Prereq: 542: 341 and Math 414 or 465; 543: 542.* Athreya, H. A. David, Ghosh, Meeden. Probability and distribution theory, common parametric families of distributions, elementary limit theorems, order statistics, central and non-central sampling distributions, introduction to the multivariate normal distribution, theory of point estimation including Bayes and minimax estimation, confidence intervals, classical and sequential hypothesis testing, and nonparametric inference.

544. Bayesian Decision Theory. (3-0) Cr. 3. Alt SS., offered 1982. *Prereq: 543.* H. T. David, Meeden. Introduction to decision theory; risk sets; admissible strategies; randomized strategies; complete classes; Bayes and minimax strategies; examples of Bayes strategies; comparison of Bayesian and classical theories; exchangeability; estimation of the multivariate normal mean.

546. Theory of Nonparametric and Asymptotic Methods. (3-0) Cr. 3. Alt S., offered 1983. *Prereq: 542.* Sukhatme. Introduction to nonparametric problems; 1-sample, 2-sample and c-sample problems; tests based upon sample distribution functions, K-S and C-S tests; rank tests, tests for location, scale and independence, local properties of rank tests. Convergence of a sequence of a random variable and a sequence of distribution functions; limit theorems; asymptotic distributions of sample quantiles, U-statistics, rank tests, chi-square and other goodness of fit tests, Chernoff-Savage theorem, asymptotic efficiency of tests.

579. Introduction to Computer Hardware and Software Systems for Statistical Computing. (1-0) Cr. 1. F. *Prereq: Graduate classification in statistics or consent of instructor.* Kennedy. Designed to introduce students to the languages and conventions required for the use of the leading software systems in statistical computing. Both batch and interactive modes of usage are considered.

580. Statistical Computing. (3-0) Cr. 3. F. *Prereq: 500, 542 and knowledge of a scientific programming language.* Kennedy. Seminumerical and numerical methods used in statistical computing. Application areas discussed include probability function approximation, simulation, and linear and nonlinear least squares methods.

590. Special Topics. Cr. Var.
A. Theory
B. Methods
C. Design of Experiments
D. Design of Surveys

Courses for Graduate Students, major or minor

601. Advanced Statistical Methods. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 501 and 447 or 543.* C. P. Cox. Linear model regression analyses: general orthogonal polynomials, differential variance regression, reverse estimation, essentially linear regression. Parametrically non-linear regression: Gauss-Newton and Marquardt procedures. Multivariate analyses for continuous and discrete data. Analyses of higher order contingency table data.

611. Advanced Linear Model Theory. (3-0) Cr. 3. F. *Prereq: 511, 543, course in matrix algebra.* Harville, Kempthorne. Advanced theory of least squares and best linear unbiased estimation, non-central chi-square and F distributions, distribution of linear and quadratic forms, F test, confidence regions, extensions of best linear unbiased estimation theory to mixed and random models and to non-standard settings, biased estimation, recursive estimation, inference for variance components.

612. Advanced Design of Experiments. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 512, 611.* Kempthorne, Harville. Advanced randomization theory of experimental designs, Galois fields and use of these, mathematics of factorial designs, general treatment of partially balanced designs, including quasi-factorials and other types, designs for 2-way error control, sequences of treatments, changeover designs, general theory of optimal design, optimality of certain balanced designs.

621. Advanced Theory of Survey Sampling. (3-0) Cr. 3. Alt. S., offered 1983. *Prereq: 522.* Advanced topics of current interest in design of surveys and analysis of survey data; unequal probability sampling with and without replacement; criteria for choice of survey strategies including sufficiency, likelihood, and admissibility; super population models and their role in choice of optimal strategies; review of recent literature.

639. Stochastic and Abstract Programming. (3-0) Cr. 3. Alt. SS., offered 1983. *Prereq: 540.* H. T. David, Sposito. Distribution of game values and program optima, models for programming under uncertainty. Dual and weakly dual programs in linear spaces. Applications in probability and statistics.

642. Measure Theory and Probability. (3-0) Cr. 3. S. *Prereq: 542, Math 514.* Athreya, Isaacson. Probability measure and distribution functions; random variables; characteristic functions; laws of large numbers; asymptotic distributions; martingales.

643. Theory of Estimation and Testing of Hypotheses. (3-0) Cr. 3. F. *Prereq: 543, 642.* Ghosh, Meeden. Asymptotic theory of maximum likelihood estimation; elements of decision theory; sufficiency; unbiased estimation; Neyman-Pearson theory of testing hypotheses; invariance.

645. Order Statistics. (3-0) Cr. 3. Alt. F., offered 1981. *Prereq: 543.* H. A. David. Distribution theory and moments of order statistics; estimation of location and scale parameters; censoring; robust estimation; treatment of outliers; asymptotic distributions of quantiles, extremes, and linear functions of order statistics.

647. Multivariate Analysis. (3-0) Cr. 3. F. *Prereq: 543, Math 307.* Han. Multivariate normal distribution, Wishart distribution, multiple correlation, Hotelling's T^2, multivariate regression analysis, discriminant analysis, principal components, canonical correlations.

648. Seminar on Theory of Statistics and Probability. Cr. Var. *Prereq: 543.*

651. Time Series. (Econ 651) (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 538.* Fuller, Goebel. Covariance and spectral representation of time series. Stationary and nonstationary autoregressive models. Fourier and periodogram analyses. Stochastic difference equations. Estimation and distribution theory.

661. Theory of Inference. (2-0) Cr. 2. Alt. SS., offered 1983. *Prereq: 543.* Kempthorne. The historical development; significance testing; Neyman-Pearson theory; fiducial inference; types of probability, Ramsey, Jeffreys, Savage; Bayesian ideas; likelihood inference; theory of evidence; recent literature.

680. Advanced Statistical Computing. (3-0) Cr. 3. S. *Prereq: 580.* Kennedy. Selected methods and algorithms in the areas of unconstrained and constrained nonlinear function optimization, robust estimation, and classical multivariate analysis. Emphasis on the most recent advances in these and other areas supported by statistical computing.

699. Research.

Technology and Social Change

(Interdepartmental Minor)

Supervisory Committee: G. W. Beran, H. C. Chang, L. Fletcher, K. E. Gwiasda, S. Huang, E. C. Jones (Chair), J. Knox, S. Marley, P. Morgan, J. Murdock, M. Rahman, C. Roderuck, A. A. Smith, R. Talbot, M. Ulmer, R. Van Iten (vice-chair), D. M. Warren, L. Wilcox (vice-chair), R. Wilham, W. Wolansky

Work is offered for a minor in technology and social change under a cooperative arrangement with the following departments participating in the program: Aerospace Engineering, Agricultural Engineering, Agronomy, Animal Science, Architecture, Chemical Engineering, Chemistry, Civil Engineering, Community and Regional Planning, Computer Science, Earth Sciences, Economics, Electrical Engineering, English, Family Environment, Food and Nutrition, History, Industrial Education, Industrial Engineering, Journalism and Mass Communication, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, Philosophy, Physics, Political Science, Professional Studies in Education, Sociology and Anthropology, and Textiles and Clothing.

Students choosing to declare a minor in technology and social change will pursue a degree program in the major department. A member of the supervisory committee of the interdepartmental program technology and social change will serve on the committee guiding the student's program of study. This member should be a member of the graduate faculty, and should be from a discipline outside the field of the major area of study. He or she is to be chosen by the student in consultation with the chairman of the supervisory committee, and appointed by the dean of the Graduate College.

The committee guiding the program of study of a student declaring a minor in technology and social change will select a group of courses from the list given below. For the master of science degree, this group should be at least 10 credit hours and for the doctor of philosophy degree the minimum requirement is 15 hours. Of this requirement, 4 hours must be chosen from courses in technology and social change acceptable for graduate credit.

The group of courses selected by the student's committee to form a minor in technology and social change must be chosen from outside the major area of study. They should be designed to broaden the scope of the student's training to include the humanities, the social sciences, and technology. The program for the declared minor will be approved by the technology and social change supervisory committee.

A minor in technology and social change should be selected from the following suggested courses:

Technology and Social Change: 541, 542, 590F, 640.
Aerospace Engineering: 350, 481, 485, 571, 575.
Agricultural Engineering: 422, 430, 435, 471, 501.
Agronomy: All courses appearing in graduate catalog are acceptable.
Animal Science: All courses appearing in graduate catalog are acceptable.
Anthropology: 533, 560D, 560E, 560G.
Architecture: 311, 312, 372, 373, 473, 521G, 544I, 572, 577.
Chemistry: 331, 332, 426, 599.
Community and Regional Planning: 380, 383, 395, 405, 493, 511, 515, 520, 527, 575.
Computer Engineering: 340, 440.
Computer Science: 375, 441.
Economics: 411, 512, 520, 535, 561.
Electrical Engineering: 450, 451, 474, 476.
English: 495, 534.
Family Environment: 391, 510, 519, 521, 522, 575, 604.
Food and Nutrition: 305, 319, 410, 413, 414.
Geography: 495.
Geology: 484.
History: 436, 458, 459, 463, 480, 481, 482, 489, 591C, 592.
Industrial Education: 502, 554, 615, 644, 652, 657.
Industrial Engineering: 404, 424, 425, 475, 504, 505, 511, 515, 527, 552, 624.
Journalism and Mass Communication: 425, 515, 545, 590G, 590I, 590K.
Materials Science and Engineering: All courses appearing in graduate catalog are acceptable.
Meteorology: 406, 531.
Nuclear Engineering: 401, 484, 541, 654.
Philosophy: 380, 431, 480.
Physics: 304, 311, 311T, 350, 361, 364, 365, 447, 511, 524, 528, 531, 571, 572.
Political Science: 443, 444, 447, 448, 481, 543, 547, 549, 578.
Professional Studies in Education: HPC Ed 581, 584, 585, 586, 590.
Sociology: 331, 411, 415, 420, 445, 450, 464, 532, 533, 540, 550, 566, 575, 642.
Textiles and Clothing: 354, 355, 404, 465, 525, 554, 555, 565, 580.

Courses Primarily for Graduate Students, minor only, open to qualified undergraduates.

541. Technology and Social Change in Foreign Cultures. (U St 541) (3-0) Cr. 3. F. *Prereq: Senior or graduate classification.* An interdisciplinary study of technology and the effects of technological change within economically less developed countries. Analysis of the role of science and technology in development; implications and consequences of technology transfer; issues and constraints involved in choosing an appropriate technology.

542. World Food Issues. (U St 542) (3-0) Cr. 3. S. *Prereq: 541 or graduate classification.* An interdisciplinary study of societal, human and technological aspects of the world food situation. The study examines four issues: the present world food situation; the challenge of meeting future food requirements; constraints to growth and change, and professional, scientific, and technical strategies for development.

590F. Special Topics: Technology and Social Change. (U St 590F) Cr. var. F.S.SS. *Prereq: 541.* Individual study on topics involving technology and social change in foreign cultures.

Course for Graduate Students, minor only

640. Seminar in Technology and Social change. (U St 640) Cr. 1-3 each time elected. S.SS. *Prereq: 541.* Consideration of problems and issues arising from the effects of technological change in foreign cultures. Issues and problems vary each time offered.

Telecommunicative Arts

For description of courses, see *Speech.*

Textiles and Clothing

Agatha L. Huepenbecker, Head of Department

The Graduate Faculty

Members: Huepenbecker, Winakor

Associate Members: Farrell, Kim, Kundel

The department offers the degree Master of Science with a major in textiles and clothing, and a minor to students taking major work in other departments. The department participates in the interdapartmental minor programs of Gerontology and Technology and Social Change (see Index).

Prerequisite to major graduate work is the completion of selected courses in art and design, the humanities, physical and social sciences, and textiles and clothing. The specific prerequisites will depend upon the nature of the work the student wishes to pursue. A thesis is required.

Courses for Graduate Students, minor only

354. History of Costume I. (3-0) Cr. 3. F.S., alt. SS., offered 1983. *Prereq: Hist 201 or Art 280.* Clothing styles of men, women, and children in western civilization from prehistoric times to present; factors associated with origin, adoption, and abandonment of styles.

355. History of Textiles I. (3-0) Cr. 3. F.S., alt. SS., offered 1982. *Prereq: 204; Hist 201 or Art 280.* Aesthetic development of world textiles including historic and traditional textiles. Textiles for costume and for enrichment of architectural interiors. Societal factors influencing design and production of ornamental textiles.

404. Advanced Textiles. (3-0) Cr. 3. F.S. *Prereq: 204.* Fabric properties as determined by fiber structure and composition, fabric formation, finishes. Emphasis on new developments.

464. Family Clothing Consumption. (3-0) Cr. 3. F.S., alt. SS., offered 1982. *Prereq: Econ 201, junior classification.* Theories of clothing consumption; factors affecting family expenditures for clothing and household textiles; study of standard budgets.

465. Sociological and Psychological Aspects of Clothing and Textiles I. (3-0) Cr. 3. F.S., alt. SS, offered 1983. *Prereq: 165, Psych 101, Soc 134.* Functions and meanings of dress in contemporary societies and subcultures. A social science research emphasis.

468. Clothing for Special Needs. (3-0) Cr. 3. F. *Prereq: 221 or 222; 165 or F E 360.* Analysis of clothing problems as related to physical, social, and psychological well-being of people with special needs. Selection and design of functional clothing to meet the specific requirements of children, the elderly, or individuals who may be physically or mentally handicapped.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

500. Short Course. Cr. arr. SS.
A. Textiles
B. History of Textiles
C. Clothing Construction and Patternmaking
D. Fashion Design
E. History of Costume
F. Sociological and Psychological Aspects of Clothing and Textiles
G. Economic Aspects of Clothing and Textiles
I. Fashion Merchandising

504. Textile Science. (3-0) Cr. 3. F. *Prereq: 404.* Scientific principles and theories involved in fiber formation, fiber and fabric structures, color, and finishes; analysis of fabric geometry and deformation.

521. Experimental Clothing Construction. (2-3) Cr. 3. F. *Prereq: 6 credits in clothing construction/patternmaking.* Problem solving approach to clothing construction and fitting. Use of different fabrics, time studies and alternative techniques.

525. Advanced Patternmaking. (1-5) Cr. 3. S. *Prereq: 345, 6 credits in patternmaking.* Use of flat pattern and draping techniques for more intricate designs of sleeves, bodices, dresses. Methods of drafting basic pattern blocks and pattern grading procedures. Patternmaking for unlined coat or jacket; for men's wear and or children's wear.

545. Advanced Costume Design. (2-0) Cr. 2. S. *Prereq: 6 credits from 345, Phil 340, Psych 312.* Analysis of costume in the light of theories formulated by writers on aesthetics, art history, costume history, and perception.

554. History of Costume II. (2-0) Cr. 2. F. *Prereq: 354.* Study of garments in the historic collection and their relationship to other sources of information; research techniques; individual study of selected periods.

555. History of Textiles II. (2-0) Cr. 2. S. *Prereq: 355.* Technical aspects of fabric structure and applied textile design within and across cultures; evolution of classic and individual textile motives; research techniques, individual topics.

557. Restoration and Conservation of Textiles. (1-2) Cr. 2. Alt. F., offered 1982. *Prereq: 304; 354 or 355.* Purpose and function of historic collections; problems in acquisition and cataloging, restoration; and preservation techniques for maintenance, storage, and display of historic textiles and costumes.

565. Sociological and Psychological Aspects of Clothing and Textiles II. (2-0) Cr. 2. F. *Prereq: 465.* Readings in sociological and psychological literature applicable to clothing and textiles. Written and oral presentations of reading and research. Emphasis on theory.

580. International Study Tour. Cr. 1 to 5. Every third SS., offered 1983. *Prereq: 354, 355.* A short period of orientation (lectures, film, discussion, short field trips, and study) before travel to observe garments and textiles in mills, factories, homes, stores, laboratories, and museums. Countries studied and visited will vary.

590. Special Topics. Prereq: Permission of department head and instructor(s) concerned. Cr. arr.
A. Textiles
B. History of Textiles
C. Clothing Construction and Patternmaking
D. Fashion Design
E. History of Costume
F. Sociological and Psychological Aspects of Clothing and Textiles
G. Economic Aspects of Clothing and Textiles

Courses for Graduate Students, major or minor

610. Seminar. Cr. 1 S.

656. Asian Costume and Textiles. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 555, Asian history or Asian art history.* Group and individual studies of traditional costume and textiles of selected Asian countries. Includes China, Japan, Korea, Southeast Asia, India, Indonesia and selected Middle Eastern countries. Topics may vary with semester of offering.

657. Ethnic or Regional Costume and Textiles. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 555.* Group and individual studies of traditional costumes and textiles of selected folk cultures. Includes cultures of Europe, the Americas, Africa, and Oceania. Topics may vary with the semester of offering.

699. Research.

Transportation Planning

(Interdepartmental Major)

Robert L. Carstens, Chair, Supervisory Committee

Supervisory Committee: C. P. Baumel, K. A. Brewer, M. R. Hill, H. D. Meeks, D. B. Vellenga, R. I. Wessel, W. F. Woodman

Work is offered for degree Master of Science (thesis and non-thesis options) with major in transportation planning under a cooperative arrangement with various departments including Civil Engineering, Community and Regional Planning, Economics, and the School of Business Administration, Industrial Engineering, Political Science, and Sociology. Opportunities are afforded for research in such areas as modeling and performance of transportation systems, techniques for urban and regional transportation system planning, environmental and social policy analysis of transportation systems, transportation policy analysis, anaylsis of transportation technologies, commodity distribution, public administration of the transportation planning process, regional development and transportation system interrelationships, transportation economics and finance, and planning for logistics management.

Students majoring in transportation planning will choose a major professor from the graduate faculty membership of the cooperating departments and will develop a program of study under the guidance of a committee nominated by the administrative department head, approved by the departmental transportation planning supervisory committee representative, and appointed by the dean of the Graduate College. For administrative purposes, students will be in the departments of their major professors.

A student must complete at least 30 credit hours of acceptable work. At least 20 credits for the thesis option and 24 credits for the non-thesis option shall be selected from a list of courses approved for inclusion in a program in transportation planning. The foreign language requirement, if any, is established on an individual basis by the student's program of study committee.

Courses Primarily for Graduate Students, major only

690. Advanced Topics. Cr. 1 to 2. Creative component for non-thesis Master of Science degree.

691. Seminar in Transportation Planning. (1-0) Cr. 1 each time taken. F.S.

699. Research.

University Studies

George C. Christensen, Vice President for Academic Affairs

Certain interdisciplinary courses are offered through University Studies. at the discretion of the Vice President for Academic Affairs and the University Curriculum Committee. No major is available in University Studies, but credit obtained through University Studies offerings may be applied toward a degree in any of the colleges, consistent with the stipulations of the student's curriculum.

Requests to make use of University Studies 101, 290, 301, and 490 should be directed to the Vice President for Academic Affairs and should be accompanied by a positive recommendation from the department heads and deans of the instructors making the request. The University Curriculum Committee will consider all requests and recommend to the Vice President regarding their disposition after consultation with relevant college and University committees.

Courses for Graduate Students, minor only

421. Policies and Procedures in Environmental Analysis. (Env S 421) (2-2) Cr. 3. F. *Prereq: 221, 222.* History of environmental legislation and the development of environmental assessment. Interrelationships among federal, state, and local agencies; the public and the courts in implementing environmental laws and regulations. Techniques for the analysis and preparation of environmental impact statements under the National Environmental Policy Act. Field trips.

425. Environment and Society. (Env S 425) (3-0) Cr. 3. SS. *Prereq: 10 hours in social or natural sciences.* An in-depth analysis of natural and human-modified ecosystems with attention on energy, resources, food, and population as they relate to society and the quality of human environments.

Courses Primarily for Graduate Students, open to qualified undergraduates.

541. Technology and Social Change in Foreign Cultures. (TSC 541) (3-0) Cr. 3. F. *Prereq: Senior or graduate classification.* An interdisciplinary study of technology and the effects of technological change within economically less developed countries. Analysis of the role of science and technology in development; implications and consequences of technology transfer; issues and constraints involved in choosing an appropriate technology.

542. World Food Issues. (TSC 542) (3-0) Cr. 3. S. *Prereq: 541 or graduate classification.* An interdisciplinary study of societal, human and technological aspects of the world food situation. The study examines four issues: the present world food situation; the challenge of meeting future food requirements; constraints to growth and change; and professional, scientific, and technical strategies for development.

590. Special Topics. Independent study on topics of an interdisciplinary nature. Intended primarily for graduate students.
F. Technology and Social Change (TSC 590F)

Course for Graduate Students, minor only

640. Seminar in Technology and Social Change. (TSC 640) Cr. 1-3 each time elected. S.SS. *Prereq: 541.* Consideration of problems and issues arising from the effects of technological change in foreign cultures. Issues and problems vary each time offered.

Veterinary Anatomy

J. Carithers, Chair of Department

The Graduate Faculty

Members: Bal, Cholvin, Christensen, Dellmann, Ghoshal, Uemura

Associate Members: Adams, Carithers, Jacobson, Magilton (Emeritus)

The department offers work for the degrees Master of Science and Doctor of Philosophy with a major in veterinary anatomy, and minor work for students majoring in other departments.

Cooperative programs between Veterinary Anatomy and the Biomedical Engineering Program are provided jointly under sponsorship by the colleges of Engineering and Veterinary Medicine. See *Biomedical Engineering* for requirements. The department also participates in the interdepartmental program in Molecular, Cellular and Developmental Biology.

Fundamental knowledge of anatomy, biochemistry, chemistry, mathematics, physiology, and zoology is considered prerequisite for major study in the department.

Foreign language requirements may be established by the student's graduate advisory committee.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

509. Systematic Anatomy. (1-3 or 2-6) Cr. 2 or 4. SS. *Prereq: One year of college biology, permission of instructor.* For non-anatomy majors.
A. Ruminant Anatomy. Cr. 4.
B. Nonruminant Anatomy. Cr. 4.
C. Avian Anatomy. Cr. 2.

511. Neuroanatomy. (2-4) Cr. 4. Alt. F., offered 1982. *Prereq: 10 credits in biological science, permission of the instructor.* Gross and microscopic anatomy of the central nervous system including the organs of special sense.

515. Anatomy of Laboratory Animals. (2-3) Cr. 3. Alt. S., offered 1982. *Prereq: One year of college biology.* Gross anatomy and histology of laboratory animals.

520. Structure and Fine Structure of Animal Tissues and Organs. (3-6) Cr. 6. Alt. S., offered 1982. *Prereq: 10 credits in biological science, permission of the instructor.* Study of the morphology of cells, tissues, and organs of domestic animals at the light and electron microscopic level.

521. Advanced Gross Anatomy. (2-9) Cr. 5. S. *Prereq: Bachelor's degree in a biological science and permission of instructor.* Systematic and topographic study and dissection of the horse, ruminant, and pig.

590. Special Topics. Cr. 1-5.
A. Gross Anatomy
B. Microscopic Anatomy
C. Developmental Anatomy
D. Neuroanatomy

Courses for Graduate Students, major or minor

690. Advanced Topics. Cr. 1-3.
A. Gross Anatomy
B. Microscopic Anatomy
C. Developmental Anatomy
D. Neuroanatomy

698. Seminar. Cr. 1.

699. Research.
A. Gross Anatomy
B. Microscopic Anatomy
C. Developmental Anatomy
D. Neuroanatomy

Veterinary Clinical Sciences

Wallace M. Wass, Head of Department

The Graduate Faculty

Members: Emmerson (Emeritus), Pearson, Wass

Associate Members: Carithers, Evans, Grieer, Hill, Lundvall

The department offers work for the degree master of science with major in veterinary clinical science, and minor work for students majoring in other departments. Within the veterinary clinical sciences major, the student may specialize in veterinary medicine, surgery, radiology, or theriogenology.

Both thesis and nonthesis options are available.

A satisfactory reading knowledge of one foreign language is strongly recommended. The department uses the standardized examinations provided by Educational Testing Service for this purpose. However, the department will accept meaningful collateral work in lieu of a foreign language if this is recommended by the student's program of study committee.

Prerequisite to major graduate work is graduation from an approved college of veterinary medicine.

Course for Graduate Students, minor only

443. Large Animal Orthopedics. (2-0) Cr. 2. S. *Prereq: Third-year classification in veterinary medicine.* Orthopedic disesaes of large domestic animals.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

590. Special Topics. Cr. 1 to 3. *Prereq: Permission of instructor.*
A. Medicine
B. Surgery
C. Theriogenology
D. Radiology
E. Anesthesiology

604. Seminar. Cr. I. F.S.

640. Advanced Radiology. (2-0) Cr. 2. F. *Prereq: 448.* Detailed principles of clinical radiology with particular reference to radiographic interpretation.

644. Advanced Animal Reproduction. (1-3) Cr. 2. Alt. S., offered 1982. *Prereq: 447, 450.* A detailed study of reproductive diseases of the male animal.

645. Advanced Animal Reproduction. (1-3) Cr. 2. Alt. S., offered 1983. *Prereq: 447, 450.* A detailed study of reproductive diseases of the female animal.

671. Advanced General Surgery. (1-3) Cr. 2. Alt. S., offered 1982. *Prereq: 441.* An advanced course designed to investigate and discuss the responses of the body to surgical and anesthetic procedures.

672. Advanced Special Surgery. (1-3) Cr. 2. Alt. S., offered 1983. *Prereq: 449.* Advanced procedures in both clinical and research techniques in abdominal, thoracic, orthopedic, cardiovascular, and neurological surgery.

676. Advanced Medicine. (2-0) Cr. 2. Alt. F., offered 1981. *Prereq: 446.* Principles of general medicine. A study in depth of factors that contribute to the development of clinical signs as related to the pathogenesis of disease.

677. Advanced Medicine. (2-0) Cr. 2. Alt. F., offered 1982. *Prereq: 446.* An advanced study of metabolic diseases.

678. Laboratory Animal Medicine and Pathology. (V Pth. 678) (2-0) Cr. 2. Alt. SS., offered 1983. *Prereq: 446.* Detailed principles of medicine and pathology of laboratory animals.

699. Research.
A. Medicine
B. Surgery
C. Theriogenology
D. Radiology
E. Anesthesiology

Veterinary Microbiology and Preventive Medicine

T. T. Kramer, Chair of Department

The Graduate Faculty

Members: Beran, Gough, Harris, Hofstad, Kaeberle, Kramer, Mengeling, Packer, Pier, Reed, Ross, Switzer, Thoen, VanDerMaaten, Woode

Associate Members: Abou-Gabal, Hill, Platt

The department offers opportunities for the degree Master of Science with majors in veterinary microbiology and veterinary preventive medicine. The degree Doctor of Philosophy with major in veterinary microbiology can also be earned. Courses are also offered to students doing major work in other departments.

Candidates for departmental majors must possess the D.V.M. degree or an undergraduate degree in biomedical sciences with emphasis in medical microbiology.

The department strongly recommends that applicants take the Graduate Record Examination and will use GRE scores as an important element in the selection of graduate students. The program of study for the Ph.D. degree must contain a foreign language requirement or a significant cultural component in a collateral field of study. The foreign language option can be satisfied by one year of college level courses in a foreign language (grade A or B) or a passing score on the ETS graduate student foreign language examination, or a test of scientific reading competence, administered by the department. The alternative cultural component may be in the general areas of language and communication, philosophy and the scientific method, logic, history of science and culture, human values, etc. The foreign language or cultural component requirement will be specifically determined by the student's program of study committee, with approval of the chair of department. For students whose native language is not English, the ability to communicate adequately (as certified by the Department of English) will be required during the first year of study.

The department also participates in the interdepartmental programs of Immunobiology and Molecular, Cellular and Developmental Biology (See Index).

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

520. Medical Immunology I. (Bact. 520) (Imbio. 520) (2-0) Cr. 2. F. *Prereq: 381 or Micro 300.* Kaeberle. The immune response, antigens, antibodies, antigen-antibody interactions and other effector mechanisms of resistance to disease.

520L. Medical Immunology Laboratory. (Imbio 520L) (0-6) Cr. 2. F. *Prereq: Credit or classification in 520.* Kaeberle. Principles of serology and detection of immunologic reactivity as applied to diagnosis of disease and research in immunology.

522. Principles of Epidemiology. (3-0) Cr. 3. F. *Prereq: 381 or Micro 310.* Disease transmission in animal and human populations. Epidemic investigations. Vital statistics and disease reporting.

524. Veterinary Medical Mycology. (Micro 524) (2-6) Cr. 4. *Prereq: 382 or Bot 596; permission of instructor.* Gabal. Fungi pathogenic for animals and the diseases with which they are associated. Methods of isolation and identification.

526. Advanced Veterinary Virology. (Micro. 526) (2-6) Cr. 4. F., offered 1982. *Prereq: 382 or Micro 408; permission of instructor.* Pathogenesis and ecology of viral infections and the procedures for diagnosis and control of viral diseases.

590. Special Topics. Cr. 1 to 3. *Prereq: 382.*

Courses for Graduate Students, major or minor

604. Seminar. (1-0) Cr. 1. F.S. Packer.

625. Pathogenic Bacteriology. (2-6) Cr. 4. S. *Prereq: 381.* Packer, Thoen. Advanced study of the pathogenic bacteria and technical procedures used in research.

626. Basic Mechanisms in Animal Virology. (2-6) Cr. 4. Alt. F., offered 1981. *Prereq: 526 or Micro 408; permission of instructor.* Advanced study of animal virus host-cell interactions and technical procedures utilized in animal virus research.

629. Medical Immunology II. (Imbio 629) (4-0) Cr. 4. S. *Prereq: 520; 6 credits in biochemistry; permission of instructor.* Kaeberle. Role of immunologic mechanisms in health and disease. The immunologic system, the immune response, biologic amplification, and factors regulating immunologic processes.

631. Immunologic Disease. (V Pth 631) (Imbio 631) (2-0) Cr. 2. Alt. SS., offered 1982. *Prereq: 629 and V Pth 653.* Kaeberle, Kluge, Cheville. Known and theoretical bases for immunologic diseases including mechanisms and physiopathologic alterations associated with disease processes.

699. Research.

Veterinary Pathology

John P. Kluge, Chair of Department

The Graduate Faculty

Members: Glock, Greve, Jeska, Kluge, O'Toole, Ramsey (Emeritus), Zimmermann

Associate Members: Barnes, Carson, Cassidy, Cheville, Flatt, D. L. Graham, Hagemoser, Kemp, Lloyd, Moon, Richter, M. G. I. Riley, Seaton, Stahr

The department offers work for the degrees Master of Science and Doctor of Philosophy with major in veterinary pathology, and minor work for students majoring in other departments. Within the veterinary pathology major the student may specialize in veterinary parasitology or veterinary toxicology.

Prerequisite to major graduate work is the completion of an undergraduate curriculum leading to the degree Doctor of Veterinary Medicine. This requirement may be waived for those individuals wishing to specialize in toxicology or parasitology with the approval of the major professor and the chairman of the department.

The degree Master of Science with thesis requires the completion of a minimum of 30 graduate credits. It is possible to study for the degree Master of Science on a nonthesis basis. This option requires the completion of a minimum of 40 graduate credits, of which at least 10 must be earned in course work outside the department.

The foreign language requirement will be decided by the student's program of study committee, with the approval of the chairman of the department. For students whose native language is not English, the ability to communicate adequately in English (as certified by the Department of English) will be required.

Minor work is recommended in other departments of the College of Veterinary Medicine or departments or programs in other colleges.

The department also participates in the interdepartmental program of Immunobiology. (See Index.)

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates.

551. (371 DL) General and Systemic Pathology. (4-3) Cr. 5. F. *Prereq: V An 301, 302; or Zool 322.* Graduate study in conjunction with 371. Open only to students who do not have, or are not pursuing, the D.V.M. degree. Basic pathology with emphasis on disease in animals.

554. (426 DL) Veterinary Toxicology. (3-0) Cr. 3. S. *Prereq: 371.* Graduate study in conjunction with 426. Disease processes in animals caused by toxicants, differential diagnostic and therapeutic procedures.

556. Methods in Toxicology. (2-0) Cr. 2. F. *Prereq: 10 credits in biology, permission of instructor.* Application and interpretation of specific toxicology tests for the determination of harmful effects of poisonous substances.

557. (376 DL) Veterinary Parasitology. (5-3) Cr. 6. F. *Prereq: 371 or 551.* Graduate study offered in conjunction with 376. Open only to students who do not have, or are not pursuing, the D.V.M. degree. Parasitisms of veterinary importance, including the disease process and principles of control.

560. Immunoparasitology. (Zool 560, Imbio 560, Micro 560) (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: Courses in immunology and parasitology.* Mechanisms of host-parasite relationships that affect the life cycle of the parasites. Protozoa and helminths considered.

590. Special Topics. Cr. 1 to 3. F.S.SS. *Prereq: Permission of instructor.*
A. Veterinary Pathology
B. Veterinary Parasitology
C. Veterinary Toxicology
D. Radiobiology

Courses for Graduate students, major or minor.

604. Histopathology Seminar. Cr. 1. F.S.SS.

605. Topics Seminar. Cr. 1. F.

631. Immunologic Disease. (Imbio 631) (V MPM 631). See *Veterinary Microbiology and Preventive Medicine.*

641. Organic Pesticide Toxicology. (2-0) Cr. 2. Alt. F., offered 1983. *Prereq: 554, permission of instructor.* Organic pesticides as related to biologic effects in animals of economic importance, public health hazards, and environmental effects.

642. Toxicology of Heavy Metals and Trace Elements. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 554, permission of instructor.* Advanced study of heavy metal pollutants and trace elements; their effects in domestic animals, wildlife, and man.

643. Biotoxins. (3-0) Cr. 3. Alt. F., offered 1982. *Prereq: 554, permission of instructor.* Natural toxic background constituents in feeds, toxins present from management practices, pesticides of biological origin, and venoms.

644. Feed Additives Toxicology. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 554, permission of instructor.* Toxicologic effects of feed additives and natural ingredients resulting from mismanagement or accident; federal regulations.

645. Analytical Chemical Toxicology. (1-3) Cr. 2. F. *Prereq: Chem 211, 322, permission of instructor.* Analysis and interpretation of toxicant residues in animal tissues, feeds, water, soil, and other environmental specimens.

651. Advanced Post Mortem Techniques. (0-3 to 9) Cr. 1 to 3. F.S.SS. *Prereq: 376, 422.* Staff. Necropsy techniques of animals with emphasis on gross and microscopic lesions and diagnosis.

652. Pathologic Hematology. (2-2) Cr. 3. Alt. S., offered 1983. *Prereq: 425.* Pathologic changes in blood constituents of domestic animals.

653. Cellular and Experimental Pathology. (3-6) Cr. 5. Alt. S., offered 1983. *Prereq: 422, permission of instructor.* Fundamentals of the pathogenesis of the disease process with emphasis on experimental pathology and disease models.

654. Veterinary Neuropathology. (2-4) Cr. 4. Alt. F., offered 1982. *Prereq: 551, 653.* Advanced study of diseases of the nervous system.

655. Physiopathology of the Skeletal System. (2-2) Cr. 3. Alt. SS., offered 1983. *Prereq: 653.* Graham. Advanced study of the nutritional, metabolic, and infectious diseases of the skeletal system of domestic animals.

656. Neoplasia and Granulomatous Diseases. (2-4) Cr. 4. Alt. F., offered 1983. *Prereq: 376, 422.* Advanced studies of granulomatous and neoplastic lesions of domestic animals.

658. Histochemistry. (1-2) Cr. 2. Alt. SS., offered 1983. *Prereq: 422.* Histochemical reactions in tissues useful in diagnosis of diseases of animals.

660. Pathology of Parasitic Diseases. (2-3) Cr. 3. Alt. SS., offered 1982. *Prereq: 371, 376.* Gross and microscopic tissue changes caused by parasitic arthropods and helminths.

661. Pathogenic Protozoa. (2-3) Cr. 3. Alt. F., offered 1983. *Prereq: 371, 376.* Major species of pathogenic protozoa: pathogenesis, host response, and use as experimental subjects.

663. Clinical Chemistry. (2-2) Cr. 3. Alt. S., offered 1982. *Prereq: 425.* The pathophysiology, methodology, and clinical application of laboratory medicine.

678. Laboratory Animal Medicine. (V C 678). See *Veterinary Clinical Sciences.*

699. Research.
A. Veterinary Pathology
B. Veterinary Parasitology
C. Toxicology

Veterinary Physiology and Pharmacology

Donald C. Dyer, Chair of Department

The Graduate Faculty

Members: Ahrens, Allison, Argenzio, Cholvin, Dougherty, Dyer, Engen, Hembrough, Littledike, Pineda, Randic, Reece, Swenson, VanMeter, Whipp

Associate Members: Crump, Draper, Greer, Hsu, Martin

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in veterinary physiology or in veterinary physiology with pharmacology as a specialization, and minor work for students majoring in other departments.

Cooperative programs between Veterinary Physiology and Pharmacology and the Biomedical Engineering Program are provided jointly under sponsorship by the colleges of Engineering and Veterinary Medicine. See *Biomedical Engineering.* The department also participates in the interdepartmental program in Molecular, Cellular and Developmental Biology.

Fundamental knowledge of anatomy, biochemistry, chemistry, mathematics, physiology, and zoology is considered prerequisite for major study in the department.

Foreign language requirements may be established by the student's graduate advisory committee.

Courses for Graduate Students, minor only

360. General Pharmacology. (4-0) Cr. 4. F. *Prereq: 351 or 552.* General principles, drug disposition, drugs acting on the nervous, cardiovascular, renal, gastrointestinal, and endocrine systems, antimicrobials and antineoplastics.

Courses Primarily for Graduate Students, major or minor

501, 502. Selected Research Methods in Pharmacology. (0-8) Cr. 3 each. 501:F., 502:S. *Prereq: Graduate classification, permission of pharmacology staff.* Experience in pharmacologic techniques in selected pharmacology laboratories: cytochemical methods, extracellular and intracellular unit recording, microiontophoresis, spectrophoto-fluorometric analysis of biogenic amines, atomic absorption spectrometry, radioimmunoassay, gas chromatography, enzyme analysis, use of isotopes in drug studies, intestinal perfusion techniques, renal clearance methods, and isolated tissue bioassay.

531. Physiology and Pharmacology of Synaptic Transmission. (2-0) Cr. 2. Alt. S., offered 1982. *Prereq: 551, permission of instructor.* Randic and VanMeter. Anatomical distribution, actions, biochemical aspects of synthesis and degradation, release of possible transmitter substances in mammalian central nervous system. Several amino acids, acetylcholine, catecholamines, 5-hydroxytryptamine, and some peptides of interest in neurobiology. Various drugs will be introduced where their action is related to the subject under discussion.

533. Physiology and Endocrinology of Animal Reproduction. (An S 533) (3-0) Cr. 3. S. *Prereq: General physiology course.* Development of structure and function of the reproductive system. Physiologic and endocrine aspects include puberty, gametogenesis, estrous cycle, pregnancy, parturition, and the interaction of environment, thyroid and adrenal function, and nutrition with these processes.

551, 552. Advanced Vetebrate Physiology. (B M E 551, 552) (Zool 551, 552) (4-3) Cr. 5 each. 551:F., 552:S *Prereq: B M E 509 or Zool 320 and Zool 455, 455L, credit or classification in B B 404 or 420.* Primarily mammalian physiology. 551:Neurophysiology, neuroendocrine, endocrine, muscle, temperature regulation. 552: Body fluids, respiratory, renal, cardiovascular, digestion, metabolism.

560. (360 DL) General Pharmacology. (4-3) Cr. 5. F. *Prereq: V P P 551 and 552, BB 404, 405.* Graduate study in conjunction with V P P 360. General principles; drug disposition; drugs acting on the nervous, cardiovascular, renal, gastrointestinal, and endocrine systems; antimicrobials and antineoplastics.

565. Physiology and Pharmacology of the Autonomic Nervous System. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 551, 552.* Dyer. Storage, release, and receptors mediating the effects of autonomic transmitter substances; control and regulation of internal functions and visceral organs.

590. Special Topics. Cr. 1 to 7. *Prereq: Permission of instructor.*
A. Physiology
B. Pharmacology

Courses for Graduate Students, major or minor

630. Alimentary Physiology. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 552.* Crump, staff. A comparative study of ruminants and non-ruminants with emphasis on motility, secretion, digestion, and absorption.

631. Experimental Techniques in Physiology. (2-6) Cr. 4, Alt. S., offered 1982. *Prereq: 552.* Hembrough, staff. Possession of surgical skills recommended. Basic physiology in animals utilizing various techniques such as fistulas, bypasses, blood flow determinations, and others.

652. Respiratory Physiology. (2-1) Cr. 3. Alt. F., offered 1982. *Prereq: 552.* Engen. Review of current research literature on hemodynamics of respiratory system, lung mechanics, gas diffusion, surfactant, and related topics.

667. Qualitative Pharmacology: Isolated Tissues. (0-8) Cr. 4. S. *Prereq: 360 or 560, permission of instructor.* VanMeter. Laboratory experiments using a variety of isolated smooth muscle, cardiac, and nerve-muscle preparations to study qualitative drug responses. Emphasis on technique and reporting of laboratory data.

668. Quantitative Pharmacology: Bioassy. (0-8) Cr. 4. S. *Prereq: 667.* VanMeter. Pharmacological experiments designed to assay agonists and antagonists using principles and techniques of biological standardization and biostatistics.

690. Advanced Topics. Cr. 1 to 5. *Prereq: Permission of instructor.*
A. Physiology
B. Pharmacology

698. Seminar. Cr. 1. F.S.SS. Staff.

699. Research
A. Physiology
B. Pharmacology

Water Resources

(Interdepartmental Major)

Merwin D. Dougal, Chair, Supervisory Committee

Supervisory Committee: R. W. Bachmann, E. R. Baumann, G. E. Bivens, T. J. Born, G. L. Bultena, E. L. Denisen, J. D. Dodd, J. N. Hathcock, H. P. Johnson, D. Kirkham, H.D. Meeks, B. E. Nordlie, P. J. Reilly, D. M. Roberts, R. B. Talbot, J. F. Timmons, H. W. Walker

Work is offered for the degrees Master of Science (thesis and nonthesis options) and Doctor of Phylosophy with major in water resources under a cooperative arrangement with various departments including Agricultural Engineering, Agronomy, Animal Ecology, Bacteriology, Botany, Chemical Engineering, Civil Engineering, Earth Sciences, Economics, Family Environment, Food and Nutrition, Food Technology, Forestry, Horticulture, Industrial Engineering, Nuclear Engineering, Political Science, and Sociology. Minor work is offered to students taking major work in other areas. Facilities exist in several departments for fundamental research in such areas as source, distribution, and movement of water or hydrology, and hydraulics of water control facilities (water quanitity); physical, biological, and chemical properties of water (water quality); and social, legal, and economic aspects of water resource development (water resources economics and institutions).

Students majoring in water resources will choose a major professor from the graduate faculty membership of the cooperating departments and will develop the program of study under the guidance of a committee nominated by the administrative department head, approved by the departmental water resources supervisory committee representative, and appointed by the dean of the Graduate College. For administrative purposes, students will be in the department of their major professor.

For the degrees Master of Science and Doctor of Philosophy, the foreign language reuqirement, if any, is established on an individual basis by the student's program of study committee. For the nonthesis Master of Science degree, the student must complete at least 50 credit hours of acceptable work, including a WR 590 creative component acceptable to the student's program of study committee.

Water Resources Courses

The interdepartmental water resources major consists of the three-semester sequence in water resources relating to (1) water quantity, (2) water quality, and (3) water resources economics and institutions. In addition, a special topics category and a water resources seminar category are offered. The Water Resources Interdepartmental Supervisory Committee encourages appropriate use of the water resources seminar, and will make it available insofar as possible both spring and fall semester. Appropriate interdisciplinary field trips to resource locations in Iowa and the Midwest are encouraged, particularly during the summer sessions.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

577. Water Resources I. (C E 577) (3-0) Cr. 3. F. *Prereq: Permission of Water Resources Supervisory Committee.* Introduction to water resources planning. Hydrology, including source, distribution and measurement of water; water management categories and beneficial use groups; demand for water; hydraulics and water control facilities. Administered by Civil Engineering. Cooperative with Agriculture Engineering, Agronomy, and Earth Sciences.

578. Water Resources II. (C E 578) (3-0) Cr. 3. S. *Prereq: Permission of Water Resources Supervisory Committee.* Water resources planning. The role of quality in water resources: physical, chemical, and biological aspects of water and waste water. Administered by Civil Engineering. Cooperative with Animal Ecology, Botany, and Food Technology.

579. Water Resources III. (Econ. 579) (3-0) Cr. 3. S. *Prereq:Permission of Water Resources Supervisory Committee.* Water resources planning. Water management categories and beneficial use groups; water demands for various uses. Legal, economic, sociological, governmental and technical aspects of water resources planning and management. Emphasis on systems of rational allocation among competing demands for water. Administered by Economics, cooperative with Sociology, Political Science, and other cooperating departments.

590. Special Topics. Cr. Var. *Prereq: Permission of major professor in cooperating department.* Literature reviews and conference in accordance with needs and interest of the student. Creative component for nonthesis master of science degree.

690. Seminar in Water Resources Management. (1-0) Cr. 1. F.S. *Prereq: Permission of Water Resources Supervisory Committee and major professor.*

Wildlife Biology

For description of courses, see *Animal Ecology*.

Zoology

John B. Balinsky, Chair of Department

The Graduate Faculty

Members: Balinsky, Bishop, Blaustein, Brown, Buttrey, Dolphin, Drewes, Emery, Hallberg, Hoffman, Jeska, Mayfield, Mutchmor, Powell, Redmond, Shaw, Ulmer

Associate Members: Baker, Bradley, Carlson, Ellis, Farrar, Forbes, Shen, Viles

Graduate Study

The department offers work for the degrees Master of Science and Doctor of Philosophy with majors in zoology, or molecular, cellular, and developmental biology. Both degrees require the completion of original research and written thesis or dissertation. A student majoring in zoology may specialize in animal behavior; cell biology; molecular biology; developmental biology; comparative physiology; ecology; endocrinology; immunobiology; neurobiology; parasitology; physiology. In addition to the program in Molecular, Cellular and Developmental Biology, the department also participates in the interdepartmental program in Immunobiology. (See Index.)

Students entering the graduate program in the department must be committed to research and need a sound background in the biological, physical, and mathematical sciences. Applicants are required to submit Graduate Record Examination (GRE) scores for both the aptitude and the biology advanced area tests.

Specific course requirements for advanced degrees depend largely upon previous training and experience in the major area of specialization. There is no foreign language requirement for the M.S. degree. Proficiency in one foreign language is required for the Ph.D. degree. The student's committee may require additional language competence. Certification in the use of written English is also required. All graduate students must acquire teaching experience in laboratory courses as part of their graduate program.

During the summer certain graduate courses in zoology are taught, and special research projects are supervised, at the Iowa Lakeside Laboratory, Lake Okoboji.

Courses for Graduate Students, minor only

428. Cell Biology. (3-0) Cr. 3. Alt. S., offered 1982. *Prereq: 325.* Biological organization and function at the cellular level. Emphasis on biomembranes.

434. Developmental Biology. (3-0) Cr. 3. F. *Prereq: 206L, 325.* Key concepts, experiments, and observations of developmental biology.

434L. Developmental Biology Laboratory. (0-6) Cr. 2. F. *Prereq: Credit or classification in 434.* Observations and experiments on developmental aspects of selected organisms.

Courses Primarily for Graduate Students, major or minor, open to qualified undergraduates

505. (405 DL) Advanced Invertebrate Zoology. (3-0) Cr. 3 or (3-6) Cr. 5. Alt. F., offered 1982. *Prereq: 325 or 355; permission of instructor to enroll in lab.* Graduate study in conjunction with 405. In-depth study of selected invertebrate groups; analysis of research topics. Not open to students who have credit in 405.

506. Host-Parasite Systems. (Micro 506) (2-0) Cr. 2. F. *Prereq: A course in parasitology.* Detailed examination of host-parasite relationships involving parasitic helminths, protozoa and arthropods.

507. Advanced Animal Behavior. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 304.* Analysis of current research in animal behavior.

512. Vertebrate Behavioral Ecology. (A Ecl 512) See *Animal Ecology.*

528. Cellular Growth and Regulation. (3-0) Cr. 3. F. *Prereq: Courses in cell biology and biochemistry.* Cell cycle, regulation of cell growth, cell division, membranes, transport processes, and regulation of cellular activities.

534. Molecular Development and Differentiation. (3-0) Cr. 3. S. *Prereq: Courses in developmental and cell biology.* Molecular biology of eucaryotic cells emphasizing developmental events.

550. Comparative Physiology of Respiration and Circulation. (2-0) Cr. 2. Alt. S., offered 1983. *Prereq: 355.* Respiratory gas exchange by aquatic and aerial invertebrates and vertebrates. Functions of circulatory systems in gas exchanges. Emphasis on basic aspects of aquatic and aerial respiration, and adaptations to environments posing special respiratory problems.

551. Advanced Vertebrate Physiology I. (4-3) Cr. 5. F. *Prereq: 355; 320 or B M E 525; credit or classification in B B 420 or 404.* Neurophysiology, sensory systems, muscle, neuroendoctrinology, endocrinology.

552. Advanced Vertebrate Physiology II. (4-3) Cr. 5. S. *Prereq: 355; 320 or B M E 525; credit or classification in B B 420 or 404.* Cardiovascular, renal, respiratory physiology, and digestion.

554. (454 DL) General and Comparative Endocrinology. (3-0) Cr. 3 or (3-3) Cr. 4. Alt. S., offered 1983. *Prereq: 355, a course in biochemistry.* Graduate study in conjunction with 454. Chemical integration of vertebrate organisms. The structure, development, and evolution of the endocrine glands and the function and structure of their hormones. Laboratory techniques for studying hormonal phenomena.

556. (456 DL) Introduction to Neurobiology. (3-0) Cr. 3 or (3-3) Cr. 4. S. *Prereq: 355 or Psych 311; physics recommended; permission of instructor to enroll in lab.* Graduate study in conjunction with 456. Integration, coding, plasticity, and development in nervous systems.

559. (459 DL) Environmental Physiology. (3-0) Cr. 3 or (3-3) Cr. 4. Alt. F., offered 1981. *Prereq: 355; physics recommended.* Graduate study in conjunction with 459. Physiological adaptations to the environment with emphasis on vertebrates.

560. Immunoparasitology. (V Pth 560). See *Veterinary Pathology.*

590. Special Topics. Cr. 1 to 5 each time taken. *Prereq: Permission of instructor.*

Courses for Graduate Students, major or minor

610. Current Topics in Parasite Ultrastructure and Physiology. Cr. 2-3 each time taken. *Prereq: 506, permission of instructor.* Critical analysis of current literature in fine structure and physiology of parasites.

612. Current Topics in Parasite Ecology, Evolution and Systematics. (Micro 612) Cr. 2-3 each time taken *Prereq: 506, permission of instructor.* Critical study of current literature concerning special adaptations of parasites in relation to specific microenvironments, parasite population biology and behavior, modern approaches to systematics.

630. Current Topics in the Cellular and Molecular Biology of Animal Systems. Cr. 2-3 each time taken. *Prereq: 528.* Topics from cell organel function, cellular interactions, and eucaryotic molecular biology.

631. Advanced Developmental Biology. Cr. 2-3 each time taken. *Prereq: 434.* Presentations and discussion of selected research topics in developmental biology.

632. Cellular Regulation. Cr. 2-3 each time taken. *Prereq: 528 or B B 526.* In-depth analysis of selected cellular control mechanisms. Emphasis on the regulation of protein levels and the action of selected hormones on cell function.

633. Comparative Molecular Physiology. Cr. 2-3 each time taken. *Prereq: 355 and 1 year of biochemistry.* Selected topics on comparative aspects of energetics, anaerobiosis, anhydrobiosis, nitrogen metabolism, ionic and osmotic regularion. Emphasis on lower vertebrates and invertebrate animals.

650. Current Topics in Physiology. Cr. 2-3 each time taken. *Prereq: 355; permission of instructor.* Topics from comparative physiology, environmental physiology, mammalian physiology, selected physiological techniques.

654. Advanced Endocrinology. (2-0) Cr. 2 each time taken. Alt. S., offered 1982. *Prereq: 454 or 551, 552.* Selected aspects of endocrine function in vertebrates.

655. Insect Physiology. (Ent 655) See *Entomology.*

660. Current Topics in Neurobiology and Behavior. Cr. 2-3 each time taken. *Prereq: Permission of instructor.* Topics may include communication, hormones and behavior, neural integration, neuroanatomy and ultrastructure, sensory biology, social behavior, techniques in neurobiology and behavior.

690. Seminar in Zoology. Cr. 1 each time taken. Offered on a satisfactory-fail basis only.
A. Cellular, Molecular, and Developmental Biology
B. Invertebrate Zoology and Parasitology
C. Neurobiology and Behavior
D. Physiology

698. Seminar in Molecular, Cellular, and Developmental Biology. (MCDB 698) See *Molecular, Cellular, and Developmental Biology.*

699. Research.

*Courses Offered at the Iowa Lakeside Laboratory

302L. (L:101) Field Biology. (4-12) Cr. 2.5. SS. Animals in the field, with particular emphasis on their recognition and on collecting, preserving, and laboratory culture methods. Field trips. Must be taken concurrently with Bot 301L.

371L. (L:118) Field Entomology. (8-24) Cr. 5. SS. Survey of insect world including classification, life history, literature, and ecology. Emphasis on field observations, making and naming personal collection of insects. Field trips.

490Z. Independent Study. (See preceding section.)

508L, 509L. (L:103, L:104) Aquatic Ecology. (8-24) Cr. 5 each. SS. Survey of local aquatic organisms and aquatic habitats; analysis of physiographic, physical, and chemical factors. Emphasis on field work, methodology, and basic ecological principles. Field Trips.

512L. (L:107) Helminthology. (8-24) Cr. 5. SS. *Prereq: 206L, 15 credits in zoology.* Survey of cestodes, trematodes, and nematodes parasitic in wildlife, laboratory animals, and man; study of selected vectors; identification, life histories, and host-parasite relationships emphasized.

516L. (L:110) Symbiotic Relationships. Cr. 5. SS. *Prereq: 15 credits in zoology.* Field and laboratory studies of the major types of symbioses, including commensalism, parasitism, and mutualism. Emphasis on field studies of relationships involving aquatic animals of the Okoboji region. For advanced undergraduates and graduate students.

590. Special Topics. (See preceding section.)

699. Research. (See preceding sections.)

**Courses Offered at the Gulf Coast Research Laboratory, Ocean Springs, Mississippi

207G. Introduction to Marine Zoology. Cr. 4 SS. Prereq: 12 credits in biological sciences. General introduction to the marine environment; emphasis on local fauna. Field trips.

307G. Marine Invertebrate Zoology. Cr. 6. SS. *Prereq: 24 credits in zoology, including an introductory course in invertebrate zoology.* Concentrated study of free-living, marine invertebrates of the Mississippi Sound and adjacent continental shelf of the northeastern Gulf of Mexico. Emphasis on structure, classification, phylogeny, larval development, and functional processes.

320G. Marine Vertebrate Zoology and Ichthyology. Cr. 6. SS. *Prereq: 24 credits in zoology, including comparative anatomy.* General study of marine chordates, including fishes, amphibians, reptiles, birds and mammals. Emphasis on fishes.

***Written permission of the instructor is prerequisite to all courses offered at the Iowa Lakeside Laboratory. For current information concerning courses, registrations, and housing, see the annual Iowa Lakeside Laboratory Bulletin. This bulletin is usually available from participating departments after February 15. Numbers beginning with L indicate numbers used by the University of Iowa.**

****Written permission of the coordinator of the Gulf Coast Research Laboratory, 201 Bessey Hall, Iowa State University, Ames, Iowa, 50011, is prerequisite to all courses offered at the Laboratory.**

The Graduate Faculty

PARKS, W. ROBERT, President; Professor of Political Science. B.A., 1937, Berea; M.A., 1938, Kentucky; Ph.D., 1948, Wisconsin; LL.D., 1966, Berea; L.H.D., 1968, Westmar; LL.D., 1968, Drake; D.Sc., 1973, Kentucky. 1958.

***ABATZOGLOU, THEAGENIS J.,** Assistant Professor of Mathematics. B.S., 1971, California Institute of Technology; Ph.D., 1976, California (Irvine). 1976, 1978.**

***ABBOTT, ERIC A.,** Associate Professor of Journalism and Mass Communication. B.S., 1967, Iowa State; M.S., 1970, Ph.D., 1974, Wisconsin. 1974, 1977.

***ABELSON, A. GEOFFREY,** Assistant Professor of Elementary Education. B.A., 1964, M.Ed., 1970, Pennsylvania State; Ph.D., 1976, Michigan. 1976.

ABIAN, ALEXANDER, Professor of Mathematics. M.S., 1954, Chicago; Ph.D., 1956, Cincinnati. 1967.

***ABOU-GABAL, MOUSTAFA,** Associate Professor of Veterinary Microbiology and Preventive Medicine. B.V.Sc., 1962, Cairo (Eygpt); M.D.Vet., 1970, Hannover (West Germany). 1974, 1978.

ABRAHAM, WILLIAM H., Professor of Chemical Engineering. B.Ch.E., 1952, Cornell; Ph.D., 1957, Purdue. 1962, 1967.

***ADAMS, DONALD R.,** Associate Professor of Veterinary Anatomy. M.A., 1967, California State (Chico); Ph.D., 1970, California (Davis). 1974, 1976.

***ADAMS, JEAN W.,** Associate Professor of Economics. B.A., 1969, M.A., 1971, Ph.D., 1973, Illinois. 1972, 1979.

ADAMS, ROY D., Associate Professor of Economics. B.A., 1968, M.A., 1971, Ph.D., 1972, Illinois. 1972, 1978.

AHMANN, J. STANLEY, Professor of Professional Studies in Education and Chair of the Department; Professor of Psychology. B.A., 1943, Trinity; B.S., 1947, M.S., 1949, Ph.D., 1951, Iowa State. 1975.

AHRENS, FRANKLIN A., Professor of Veterinary Physiology and Pharmacology. B.S., D.V.M., 1959, Kansas State; M.S., 1965, Ph.D., 1968, Cornell. 1968, 1975.

***AIGNER, STEPHEN M.,** Assistant Professor of Sociology. B.A., 1967, Knox; M.S.W., 1969, M.A., 1972, Ph.D., 1976, Michigan. 1973, 1977.

***AKERS, ARTHUR,** Associate Professor of Engineering Science and Mechanics. B.Sc., 1953, London (England); M.Sc., 1955, Cranfield (England); Ph.D., 1969, London (England). 1975, 1980.

ALLEN, BENJAMIN J., Associate Professor of Business Administration. B.S., 1969, Indiana; M.A., 1973, Ph.D., 1974, Illinois. 1979.

***ALLEN, PHILIP M.,** Professor of Art and Design. B.F.A., 1960, M.F.A., 1961, Drake. 1967, 1979.

ALLISON, MILTON J., Professor of Veterinary Physiology and Pharmacology (Collaborator). B.S., 1953, M.S., 1954, South Dakota State; Ph.D., 1961, Maryland. 1977.

AMEMIYA, MINORU, Professor of Agronomy. B.S., 1942, California (Berkeley); M.S., 1948, Ph.D., 1950, Ohio State. 1968, 1971.

***AMOS, ROSALIE J.,** Assistant Professor of Home Economics Education; Assistant Professor of Secondary Education. B.S., 1953, Iowa State; M.S., 1960, Ph.D., 1976, Cornell. 1978.

***ANDERSON, CARL E.,** Associate Professor of Agricultural Engineering. B.S.A.E., 1962, Pennsylvania State; M.S.A.E., 1965, Arizona; Ph.D., 1975, Kansas State. 1973, 1979.

ANDERSON, DALE A., Professor of Aerospace Engineering. B.S., 1957, St. Louis; M.S., 1959, Ph.D., 1964, Iowa State. 1965, 1975.

***ANDERSON, DEAN F.,** Assistant Professor of Physical Education. B.S., 1968, M.A., 1972, Ph.D., 1978, Minnesota. 1976, 1978.

ANDERSON, E. WALTER, Associate Professor of Physics. M.A., 1961, Ph.D., 1965, Columbia. 1972, 1976.

ANDERSON, IRVIN C., Professor of Agronomy; Professor of Botany. B.S., 1951, Iowa State; M.S., 1954, Ph.D., 1957, North Carolina State. 1958, 1967.

***ANDERSON, JANET I.,** Assistant Professor of English. Ph.B., 1967, Northwestern; M.A., 1972, Ph.D., 1976, Illinois. 1978, 1979.

ANDERSON, JULIA F., Professor of Home Economics Studies; Associate Dean of the College of Home Economics. B.S., 1941, Iowa State; M.S., 1947, Washington. 1947, 1962.

ANDERSON, LLOYD L., Professor of Animal Science. B.S., 1957, Ph.D., 1961, Iowa State. 1958, 1971.

ANDRE, THOMAS, Associate Professor of Psychology; Associate Professor of Secondary Education. B.S., 1967, Massachusetts; M.A., 1970, Ph.D., 1971, Illinois. 1974, 1977.

ANGELICI, ROBERT J., Professor of Chemistry and Chair of the Department. B.S., 1959, St. Olaf; Ph.D., 1962, Northwestern. 1963, 1971.

APPLEQUIST, JON B., Professor of Biophysics. B.S., 1954, California (Berkeley); Ph.D., 1959, Harvard. 1965, 1968.

APT, LEON J., Professor of History. B.A., 1956, M.A., 1957, Arkansas; Ph.D., 1965, Chicago. 1969, 1974.

***ARCY, THOMAS H.,** Associate Professor of Industrial Education. B.S., 1964, Ferris; M.A., 1967, Michigan; Ed.S., 1970, Michigan State; Ph.D., 1974, Michigan. 1974, 1977.

ARGENZIO, ROBERT A., Associate Professor of Veterinary Physiology and Pharmacology (Collaborator). B.S., 1966, M.S., 1968, Colorado State; Ph.D., 1971, Cornell. 1978.

ARNRICH, LOTTE, Emeritus Professor of Food and Nutrition. B.S., 1944, Ph.D., 1952, California (Berkeley). 1955, 1960.

ATCHISON, GARY, Associate Professor of Animal Ecology. B.S., 1965, Michigan State; M.S., 1967, Iowa State; Ph.D., 1970, Michigan State. 1978, 1980.

ATHERLY, ALAN G., Professor of Genetics and Chair of the Department; Professor of Microbiology; Professor of Biochemistry. B.S., 1959, Western Michigan; Ph.D., 1964, North Carolina. 1968, 1976.

ATHREYA, KRISHNA B., Professor of Mathematics; Professor of Statistics. B.A., 1959, Loyola (India); Ph.D., 1967, Stanford. 1980.

ATKINS, RICHARD E., Professor of Agronomy. B.S., 1941, Kansas State; M.S., 1942, Ph.D., 1948, Iowa State. 1948, 1960.

AUSTIN, T. AL, Professor of Civil Engineering. B.S.C.E., 1967, Texas Tech; M.S., 1970, Utah State; Ph.D., 1971, Texas Tech. 1972, 1979.

AVANT, LLOYD L., Professor of Psychology. B.A., 1957, M.A., 1961, Furman; Ph.D., 1966, Kansas State. 1968, 1976.

***AVRAAMIDES, ACHILLES,** Associate Professor of History. M.A., 1963, Ph.D., 1971, Minnesota. 1965, 1977.

***BACHMANN, MARILYN D.,** Associate Professor of Animal Ecology. B.S., 1955, Ball State; M.A., 1960, Ph.D., 1964, Michigan. 1969, 1976.

BACHMANN, ROGER W., Professor of Animal Ecology. B.S., 1956, Michigan; M.S., 1958, Idaho; Ph.D., 1962, Michigan. 1963, 1971.

BAHADUR, SHYAM, Professor of Mechanical Engineering. B.E., 1957, ME., 1962, Roorkee (India); Ph.D., 1970, Michigan. 1970, 1977.

***BAILEY, THEODORE B., JR.,** Associate Professor of Statistics. B.S., 1964, Iowa State; M.S., 1969, Ph.D., 1972, Minnesota. 1973, 1978.

BAKER, DURWOOD L., Professor of Veterinary Clinical Sciences; Associate Dean of the College of Veterinary Medicine. D.V.M., 1943, Iowa State. 1947, 1959.

***BAKER, JAMES L.,** Associate Professor of Agricultural Engineering. B.S., 1966, South Dakota School of Mines; Ph.D., 1971, Iowa State. 1973, 1976.

***BAKER, JOHN RAYMOND,** Associate Professor of Zoology. B.S., 1952, B.A., 1956, M.S., 1956, Wyoming; Ph.D., 1966, Minnesota. 1965, 1970.

BAL, HARPAL, S., Associate Professor of Veterinary Anatomy. B.V.Sc., 1953, Punjab (India); M.S., 1966, Ph.D., 1969, Iowa State. 1964, 1972.

BALINSKY, JOHN B., Professor of Zoology and Chair of the Department. B.S., 1955, Witwatersrand (South Africa); Ph.D., 1959, London (England). 1976.

BANCROFT, THEODORE A., Emeritus Professor of Statistics. A.B., 1927, Florida; A.M., 1934, Michigan; Ph.D., 1943, Iowa State. 1949, 1950.

***BARCUS, PAUL W.,** Associate Professor of Nuclear Engineering; Assistant Dean of the College of Engineering. B.S., 1945, United States Naval Academy; B.S., 1948, Massachusetts Institute of Technology; M.A., 1961, East Carolina; Ph.D., 1966, Iowa State. 1966, 1969.

***BARNES, H. JOHN,** Associate Professor of Veterinary Pathology, Veterinary Medical Research Institute. B.S., 1969, D.V.M., 1970, Kansas State; Ph.D., 1976, Ahmadu Bello (Nigeria). 1975, 1978.

BARNES, RICHARD G., Professor of Physics. B.A., 1948, Wisconsin; M.A., 1949, Dartmouth; Ph.D., 1952, Harvard. 1956, 1960.

BARNES, WILFRED E., Professor of Mathematics and Head of the Department. S.B., 1949, S.M., 1950, Chicago; Ph.D., 1954, British Columbia. 1966.

***BARNHART, RUTH S.,** Associate Professor of Elementary Education. B.S., 1960, M.A., 1964, Western Michigan; Ph.D., 1975, Michigan State. 1975, 1979.

***BARTA, THOMAS A.,** Associate Professor of Industrial Engineering. B.S., 1957, Iowa State; M.S., 1962, Iowa; Ph.D., 1975, Iowa State. 1969, 1975.

BARTON, THOMAS A., Professor Emeritus of Landscape Architecture. B.S., 1941, M.L.A., 1960, Iowa State. 1955, 1962.

BARTON, THOMAS J., Professor of Chemistry. B.S., 1962, Lamar; Ph.D., 1967, Florida. 1967, 1978.

BASART, JOHN P., Professor of Electrical Engineering. B.S., 1962, M.S., 1963, Ph.D., 1967, Iowa State. 1969, 1980.

***BATAILLE, GRETCHEN M.,** Assistant Professor of English. B.S., 1966, M.S., 1967, California State Polytechnic; D.A., 1977, Drake. 1971, 1977.

***BATAILLE, ROBERT R.,** Professor of English. B.A., 1962, Rutgers; M.A., 1965, Ph.D., 1970, Kansas. 1969, 1979.

BATH, JOHN A., Professor of Psychology; Professor of Secondary Education. A.B., 1932, Peru State; M.A., 1933, Ph.D., 1942, Nebraska. 1946, 1957.

BAUM, DALE D., Associate Professor of Elementary Education. B.S., 1954, Ohio State; M.Ed., 1967, Missouri; Ed.D., 1970, Kansas. 1977.

BAUMANN, E. ROBERT, Professor of Civil Engineering; Anson Marston Distinguished Professor in Engineering. B.S.E., 1944, Michigan; B.S., 1945, M.S., 1947, Ph.D., 1954, Illinois. 1953, 1957.

BAUMEL, C. PHILLIP, Professor of Economics. B.S., 1950, M.S., 1957, Ohio State; Ph.D., 1961, Iowa State. 1963, 1970.

BAUMGARTEN, JOSEPH R., Professor of Mechanical Engineering. B.S.M.E., 1950, Dayton; M.S.M.E., 1955, Ph.D., 1958, Purdue. 1978.

***BAUSKE, ROBERT J.,** Professor of Horticulture. B.A., 1943, Carleton; Ph.D., 1966, Iowa State. 1966, 1975.

BAUTISTA, RENATO, G., Professor of Chemical Engineering. B.S., 1955, Santo Tomas (Philippines); S.M., 1957, Massachusetts Institute of Technology; Ph.D., 1961, Wisconsin. 1969, 1978.

***BEARD, JESS R.,** Professor of Elementary Education and Head of the Department. B.S., 1947, M.S., 1947, Illinois; Ed.D., 1958, George Peabody. 1967, 1970.

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BEAVERS, WILLET I., Associate Professor of Physics. B.S., 1955, M.S., 1959, Missouri; Ph.D., 1965, Indiana. 1965, 1969.

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BEITZ, DONALD C., Professor of Animal Science; Professor of Biochemistry. B.S., 1962, M.S., 1963, Illinois; Ph.D., 1967, Michigan State. 1967, 1977.

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***BENNETT, ADRIAN A.,** Associate Professor of History. B.A., 1964, Antioch; M.A., 1966, Ph.D., 1970, California (Davis). 1970, 1974.

***BENO, JOHN A.,** Associate Professor of Industrial Education. B.S., 1962, M.S., 1963, Eastern Illinois; Ph.D., 1975, Maryland. 1977.

BENSEND, DWIGHT W., Emeritus Professor of Forestry. B.S., 1937, Ph.D., 1942, Minnesota. 1947.

BENSON, DONALD R., Professor of English. A.B., 1949, Missouri (Kansas City); M.A., 1951, Colgate; Ph.D., 1959, Kansas. 1958, 1967.

BERAN, GEORGE W., Professor of Veterinary Microbiology and Preventive Medicine. D.V.M., 1954, Iowa State; Ph.D., 1959, Kansas; L.H.D., 1973, Silliman (Philippines). 1973.

***BERAN, JANICE A.,** Adjunct Assistant Professor of Physical Education. A.B., 1953, Central; M.S., 1970, Drake; Ph.D., 1977, Iowa State. 1976, 1978.

BERARD, MICHAEL F., Professor of Materials Science and Engineering. B.S., 1960, M.S., 1962, Ph.D., 1968, Iowa State. 1964, 1977.

BERGER, P. JEFFREY, Associate Professor of Animal Science. B.S., 1965, Delaware Valley; M.S., 1967, Ph.D., 1970, Ohio State. 1972, 1978.

BERGER, ROGER W., Professor of Industrial Engineering. B.S., 1958, Nebraska; M.S.I.E., 1962, Kansas State; Ph.D., 1968, Oklahoma State. 1972, 1980.

BERGLES, ARTHUR E., Professor of Mechanical Engineering and Chair of the Department. S.B., 1958, S.M., 1958, Ph.D., 1962, Massachusetts Institute of Technology. 1972.

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* Indicates Associate Member.

**The first date indicates the date of appointment to the Faculty; the second date, when the first fails to do so, indicates the date of appointment to present rank.

***BERN, CARL J.,** Associate Professor of Agricultural Engineering. B.S., 1963, M.S., 1964, Nebraska; Ph.D., 1973, Iowa State. 1968, 1976.

***BERNARD, ROBERT W.,** Professor of Foreign Languages and Literatures. B.A., 1958, St. Thomas; M.A., 1962, Ph.D., 1968, Kansas. 1965, 1976.

BEST, LOUIS, Associate Professor of Animal Ecology. B.S., 1968, Weber State; M.S., 1970, Montana State; Ph.D., 1974, Illinois. 1974, 1979.

***BHELLA, HARBANS, S.,** Assistant Professor of Horticulture (Collaborator); Assistant Professor of Agronomy (Collaborator). B.Sc., 1963, M.Sc., 1966, Punjab Agricultural (India); M.S., 1970, Ph.D., 1973, Oregon State. 1977.

BIGGS, DONALD L., Professor of Geology. B.A., 1949, M.A., 1951, Missouri; Ph.D., 1957, Illinois. 1956, 1967.

BISHOP, STEPHEN H., Professor of Zoology. B.A., 1958, Gettysburg; M.S., 1960, Duke; Ph.D., 1964, Rice. 1977, 1979.

BIVENS, GORDON, E., Professor of Family Environment. B.S., 1950, M.S., 1953, Ph.D., 1957, Iowa State. 1976.

BLACK, CHARLES A., Professor of Agronomy (Collaborator). B.S., 1937, Colorado State; M.S., 1938, Ph.D., 1942, Iowa State. 1937, 1949.

BLACK, HENRY M., Emeritus Professor of Mechanical Engineering. B.S., 1929, Iowa State; M.S., 1934, Harvard. 1929, 1946.

***BLACKMER, ALFRED M.,** Assistant Professor of Agronomy. B.S., 1971, M.S., 1973, Massachusetts; Ph.D., 1977, Iowa State. 1978, 1979.

BLAUSTEIN, JEFFREY D., Assistant Professor of Zoology. B.S., 1973, M.A., 1975, Ph.D., 1977, Massachusetts. 1979.

BLEYLE, CARL O., Professor of Music. B.M., 1957, Kentucky; M.M., 1960, Wisconsin; Ph.D., 1969, Minnesota. 1962, 1975.

***BLOCK, DAVID A.,** Associate Professor of Architecture. B.Arch., 1967, M.Arch., 1972, M.S., 1974, Iowa State. 1973, 1979.

BOAST, WARREN B., Emeritus Professor of Electrical Engineering; Anson Marston Distinguished Professor in Engineering (Emeritus). B.S., 1933, M.S., 1934, Kansas; Ph.D., 1936, Iowa State. 1934, 1948.

BOEHLJE, MICHAEL D., Professor of Economics. B.S., 1965, Iowa State; M.S., 1968, Ph.D., 1971, Purdue. 1973, 1977.

BOHLEN, JOE M., Professor of Sociology. B.S., 1947, M.S., 1948, Ph.D., 1954, Iowa State. 1947, 1958.

BOLES, DONALD E., Professor of Political Science. B.S., 1950, M.S., 1953, Ph.D., 1956, Wisconsin. 1955, 1963.

***BOND, PAUL R.,** Associate Professor of Electrical Engineering. B.S., 1952, John Brown; M.S., 1958, Ph.D., 1963, Iowa State. 1958, 1967.

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Tentative Calendar

	Fall 1981	Spring 1982	Summer 1982	Fall 1982	Spring 1983	Summer 1983
English Placement Examination (for all new graduate students whose native language is not English)	Aug. 24	Jan. 11	May 31	Aug. 23	Jan. 17	May 30
Registration for new and reentering students	Aug. 24	Jan. 11	June 1	Aug. 23	Jan. 17	May 31
Class work begins	Aug. 26	Jan. 13	June 2	Aug. 25	Jan. 19	June 1
End of fee payment period	Sep. 1	Jan. 19	June 4	Aug. 31	Jan. 25	June 3
Last day to drop a course without instructor's recommendation	Sep. 1	Jan. 19	June 8	Aug. 31	Jan. 25	June 7
Graduate English examination	Sep. 4	Jan. 21	June 10	Sep. 2	Jan. 27	June 9
Holiday, offices closed	Sep. 7	—	July 5	Sep. 6	—	July 4
Diploma slips due for next term	Oct. 16	Mar. 5	July 23	Oct. 15	Mar. 11	July 22
Last day for first deposits of thesis/ dissertation in Thesis Office	Oct. 30	Mar. 26	June 4	Oct. 29	April 1	June 3
Last day a course may be dropped without extenuating circumstances (and dean's signature)	Oct. 28	Mar. 24	July 7	Oct. 27	Mar. 30	July 1
Holiday, offices closed	Nov. 26-27	Ap. 12	—	Nov. 25-26	Ap. 4	—
Last day for advanced degree final oral examinations	Nov. 20	Ap. 16	June 25	Nov. 19	Ap. 22	June 24
Final deposit of thesis/dissertation in Thesis Office	Dec. 4	Ap. 30	July 12	Dec. 3	May 6	July 11
Registration for students who are in residence present semester	Dec. 7-11	May 6-7	—	Dec. 6-10	May 12-13	—
Examination week	Dec. 14-18	May 10-14	—	Dec. 13-17	May 16-20	—
Graduation	Dec. 19	May 15	July 24	Dec. 18	May 21	July 23
Holidays, offices closed	Dec. 24-25 Jan. 1	— May 31	— —	Dec. 23-24 Dec. 31	— May 30	— —

1981

January

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February

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March

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April

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May

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10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

June

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July

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12	13	14	15	16	17	18
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August

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September

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October

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11	12	13	14	15	16	17
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25	26	27	28	29	30	31

November

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8	9	10	11	12	13	14
15	16	17	18	19	20	21
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December

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1982

January

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24	25	26	27	28	29	30
31						

February

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28						

March

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7	8	9	10	11	12	13
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21	22	23	24	25	26	27
28	29	30	31			

April

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18	19	20	21	22	23	24
25	26	27	28	29	30	

May

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16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

June

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		1	2	3	4	5
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July

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11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

August

S	M	T	W	T	F	S
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8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

September

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12	13	14	15	16	17	18
19	20	21	22	23	24	25
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October

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November

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21	22	23	24	25	26	27
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December

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January

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16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February

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		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

March

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

April

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					1	2
3	4	5	6	7	8	9
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17	18	19	20	21	22	23
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May

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8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June

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			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
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26	27	28	29	30		

July

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					1	2
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10	11	12	13	14	15	16
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August

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7	8	9	10	11	12	13
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September

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				1	2	3
4	5	6	7	8	9	10
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18	19	20	21	22	23	24
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October

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						1
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November

S	M	T	W	T	F	S
		1	2	3	4	5
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December

S	M	T	W	T	F	S
				1	2	3
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18	19	20	21	22	23	24
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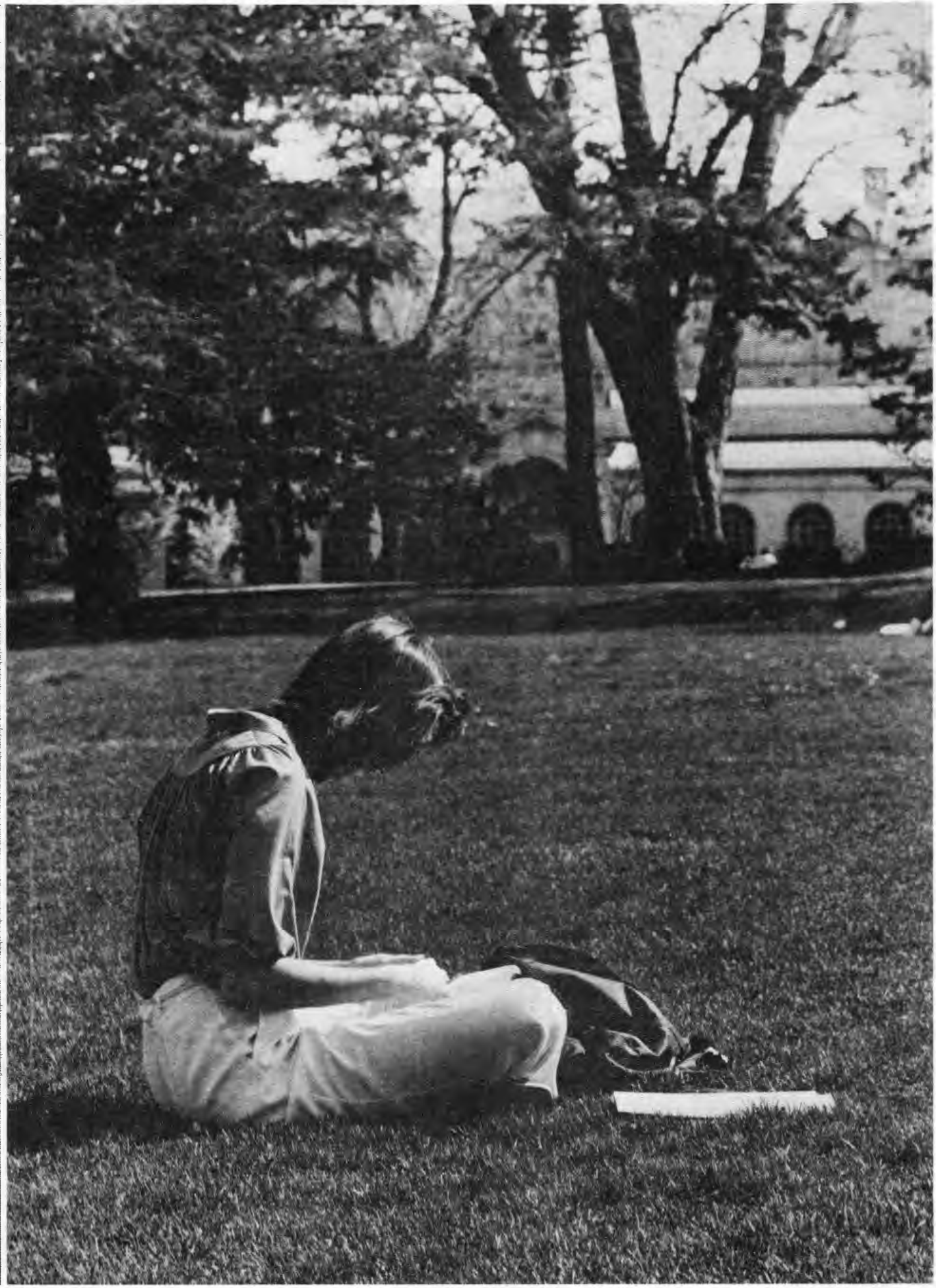

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